AUGUST 20, 1990

CHEMICAL & ENGINEERING

NEWS

Facts & Figures for Chemical R&D

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CHEMICAL & ENGINEERING
NEWS
AUGUST 20, 1990

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Special Report

C&EN's annual look at chemical R&D statistics indicates an overall sluggish growth rate with total U.S. spending projected to reach $150 billion in 1990—a mere 1% increase after adjusting for inflation. **Page 28**

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LETTERS

CHEMICAL SAFETY

Decomposition of benzyl fluoride

A 25-g bottle of commercial benzyl fluoride (CAS Registry Handbook No. 350-50-5) decomposed spontaneously in our laboratory recently. Glass fragments from the bottle and from five other adjacent bottles were scattered within the storage cabinet. The fragments were coated with an off-white resin and the odor in the cabinet was acrid. No one was injured.

The sample had been purchased more than a year ago and was kept in storage at room temperature after a 2-g portion was used. The label contained no warning about potential hazards due to instability. A material safety data sheet indicated that the compound was stable and that "hazardous polymerization will not occur."

C. K. Ingold and E. H. Ingold [*J. Chem. Soc.*, 2249 (1928)] reported the initial preparation of benzyl fluoride and described its spontaneous decomposition in glass vessels. They suggest that an autocatalytic polymerization commences at the glass surface and proceeds with the evolution of hydrogen fluoride, in some cases with almost explosive violence. Stability during distillation and storage was reported to depend on the type of glass used.

Six commercial suppliers of benzyl fluoride are listed in the 1990 edition of "Chem Sources—U.S.A.," and two are listed in the 1988 edition of "Chem Sources—International." One former supplier has notified us that it decided to discontinue supplying it as a result of two incidents involving its violent decomposition in glass bottles.

I urge that current suppliers reevaluate the potential hazard associated with the instability of benzyl fluoride in glass bottles. I strongly recommend that benzyl fluoride be used and stored in nonglass apparatus unless the glass is known to be nonreactive.

Stephen S. Szucs
Agricultural Research Division
American Cyanamid Co.
Princeton, N.J.

CAS nomenclature

What is the Chemical Abstracts Service name for 1,2-dichlorotetraphenylethane? This simple and beautifully symmetrical compound, whose name is so descriptive that a sophomore after two weeks of Organic I can go easily from the name to the structure or vice versa, has the following CAS name: benzene,1,1',1'',1'''-(1,2-dichloro-1,2-ethanediylidene)tetrakis.

Like so many other chemists, I have occasionally pondered similar cases of CAS lexicopathy and wondered at the cause of the condition. My reluctant conclusion was that this is an unanswerable problem, tied up as it is with the perversity of human nature and perhaps the perversity of the universe itself. Why does a piece of buttered bread always land on the floor face downward?

Recently, when I had the occasion to use CAS Online to search the literature for references to the above dichloride, I saw the glimmer of an answer to the above mystery. You can get all the literature references for the period between 1968 and the present for the above compound on the CA File for about $10—a fairly reasonable price. To do this search however, you need to know the CA Index name or the Registry Number. To get this you access the Registry File and draw the structure of the compound. This costs $40. By using a gobbledygook name, CAS increased its income fivefold!

Can this be the answer to the mystery of CA nomenclature? Probably not. Truly profound questions like these must have answers that go deeper than this. Perhaps the answer is to switch from buttered bread to bread and butter sandwiches.

Paul Haberfield
Professor of Chemistry
Brooklyn College
The City University of New York

CAS replies: Chemical Abstracts Service made a major revision in the assignment of chemical substance index names in 1972 with the switch to more fully systematic names and the elimination of most trivial names. This was done so

Sales and Earnings Decline for Most Canadian Chemical Companies

Weak domestic economy, both in manufacturing and markets, and an overvalued Canadian dollar have combined to hurt Canadian chemical business

Weakness has started to pervade the Canadian economy. And, along with most of their manufacturing counterparts, Canadian chemical companies are starting to reflect this weakness on their bottom lines.

Many industry leaders agree with J. E. (Ted) Newall, chairman and chief executive officer of Du Pont Canada, that Canada's manufacturing sector and most of its domestic markets will remain weak for the rest of the year. That's bad news for Canada's chemical companies. The good news: The economic situation probably won't get as bleak as it was during the 1981-82 recession.

As a result, earnings of all four of the major, publicly traded Canadian chemical companies declined during the first six months of the year, compared with the first half of 1989. Some of the drops were sharp, such as the 65% decline in Union Carbide Canada's earnings and the 56% dip in Nova Corp.'s operating income from its petrochemical, plastics, and rubber businesses.

Softness in commodity petrochemical markets contributed to both Union Carbide Canada's and Nova's problems. While Carbide Canada's sales were down only 5.9% to $211 million during the first half, net income plummeted 65% to $6.9 million. Chairman W. Norman Kissick attributes the lower sales to lower petrochemical volumes and prices.

The hit on earnings, he says, reflects the impact of the petrochemical down cycle on the earnings of Pétromont, the Montreal-based petrochemical producer that Carbide owns equally with Le Groupe SGF.

For Celanese Canada, the situation was reversed. Sales for the first half of 1990 were down 5.9% to $162 million. But net income declined only 0.8% to $21.6 million. Rare among Canadian chemical companies, Celanese Canada's earnings actually increased during the second quarter this year, even though sales slipped more than 2%.

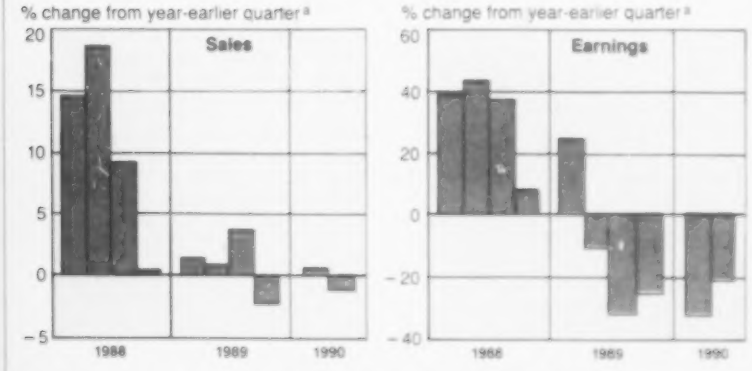
Gerald P. Elden, president of Celanese Canada, attributes part of this to polyester staple. While weak markets for the staple forced sales volumes down, lower raw material costs helped to maintain income levels. In contrast, both domestic and export markets for heavy industrial yarn were strong and the unit remained sold out.

Performance varied throughout the company. The cellulosic division's sales and earnings were down because of the higher value of the Canadian dollar, relative to other currencies, which hurt exports. Industrial product sales and earnings were up, buoyed by strong markets for cigarette filter tow. And weak methanol prices put the damper on chemical sales and earnings.

Du Pont Canada's earnings were down 25% during the first half, despite an almost 3% boost in sales. Newall says that many of the company's businesses boosted sales volumes. However, this was not enough to offset lower prices, particularly for polyethylene resins. One ray of hope: The polyethylene resin business improved in the second quarter, compared with the first quarter, and Newall expects this trend to continue for the remainder of the year.

Newall notes that the economic slowdown became more apparent in the second quarter. Domestic demand for many of Du Pont Canada's products declined. For the first half, domestic sales were off 7%, but export sales, particularly to the U.S., were up more than 40%. The free trade agreement with the U.S., says Newall, already is providing his

Earnings dropped more than sales



Note: Combined results of Celanese Canada, Du Pont Canada, and Union Carbide Canada. a Based on Canadian currency

Canadian chemical companies head for poor year

$ Millions[a]	Net sales	Change from 1989[b]	Net income[c]	Change from 1989[b]	Profit margin[d] 1990	Profit margin[d] 1989
SECOND-QUARTER 1990						
Celanese Canada	$ 84.2	−2.3%	$ 10.8	4.1%	12.8%	12.0%
Du Pont Canada	349.8	1.1	22.5	−12.6	6.4	7.4
Nova Corp.[e]	743.6	0.1	82.1	−46.1	na	na
Union Carbide Canada	104.6	−7.8	0.8	−89.4	0.7	6.4
FIRST-HALF 1990						
Celanese Canada	$ 161.9	−5.9%	$ 21.6	−0.8%	13.3%	12.7%
Du Pont Canada	653.8	2.9	40.1	−25.3	6.1	8.5
Nova Corp[e]	1469.0	−3.7	156.4	−56.3	na	na
Union Carbide Canada	211.1	−5.9	6.9	−65.4	3.3	8.9

a $1.00 = $1.170 Canadian (second quarter) and $1.176 Canadian (first half). b Based on Canadian currency. c Based on continuous operations and excluding extraordinary items. d Net income as percentage of sales. e Includes petrochemical, plastics, and rubber operations only. Nova does not break out net income by division. Income shown is operating income, which does not compare with net income of other companies. na = not applicable.

company with new business opportunities.

How strong those opportunities will be over the short term remains to be seen. Newall concedes that near-term prospects depend on demand in the U.S. But there are signs that some of Du Pont Canada's important U.S. markets are softening.

Meanwhile, high interest rates and an overvalued Canadian dollar are hurting Du Pont Canada's domestic customers. As a result, Newall calls the outlook for the rest of the year "uncertain." But, he says, "We expect a weaker last half."

Most leaders in the Canadian chemical industry agree with him. Carbide Canada's Kissick, for instance, sees no improvement in petrochemical profits for the balance of the year. And Celanese Canada's Elden says he doesn't expect this year's earnings to equal those of 1989.

Earl Anderson

Indonesia launches petrochemicals expansion

In an effort to reduce imports of basic chemicals and their derivatives, Indonesia has embarked on an ambitious petrochemical expansion binge. The country expects that more than $6 billion will be invested in its basic chemical industry over the next five years.

This new investment likely will support a 13% annual growth rate for Indonesia's chemical industry over that time span and provide more than 35,000 new jobs. It also may triple the value of Indonesia's chemical exports. The problem is that other Asian nations have their own petrochemical expansion plans in the works. As a result, the danger of overcapacity in the region is a very real one.

Most of the $6 billion is earmarked for Indonesia's petrochemical industry. However, some of it will go into fine and specialty chemicals and to boost the country's ability to process its cellulose resources, agricultural products, and waste.

Many of Indonesia's petroleum-derived downstream industries, such as polyvinyl chloride pipe and synthetic fibers, are already well developed. The country already has 56 chemical plants that produce about $4 billion worth of chemicals per year. Chemical exports run well over $550 million annually.

Indonesia's basic petrochemical industry, however, has lagged behind. The country produces enough urea, ammonia, and methanol, but still relies heavily on imports for most other petrochemicals. For instance, it imports most of the high-volume, general-purpose resins, including both high- and low-density polyethylene, polypropylene, polystyrene, and polyvinyl chloride. However, with its new petrochemical investment, Indonesia expects to become self-sufficient in petrochemicals within five years.

The plants scheduled to be built in Indonesia run the gamut of the petrochemical spectrum. Shell, C. Itoh, and Mitsubishi, for instance, are part of a Dutch-Japanese-Indonesian consortium that will build an olefins complex at Cilacap in Central Java. When it comes on stream in 1994, the $1.5 billion complex will produce polyethylene, polypropylene, monoethylene glycol, diethylene glycol, and butadiene.

Dow Chemical will be a joint-venture partner in a $20 million plant that is scheduled to be on stream next year in Merak, West Java. The unit will produce 20,000 metric tons per year of general-purpose and high-impact polystyrene. It will get its raw material from a styrene plant that also is being built in Merak.

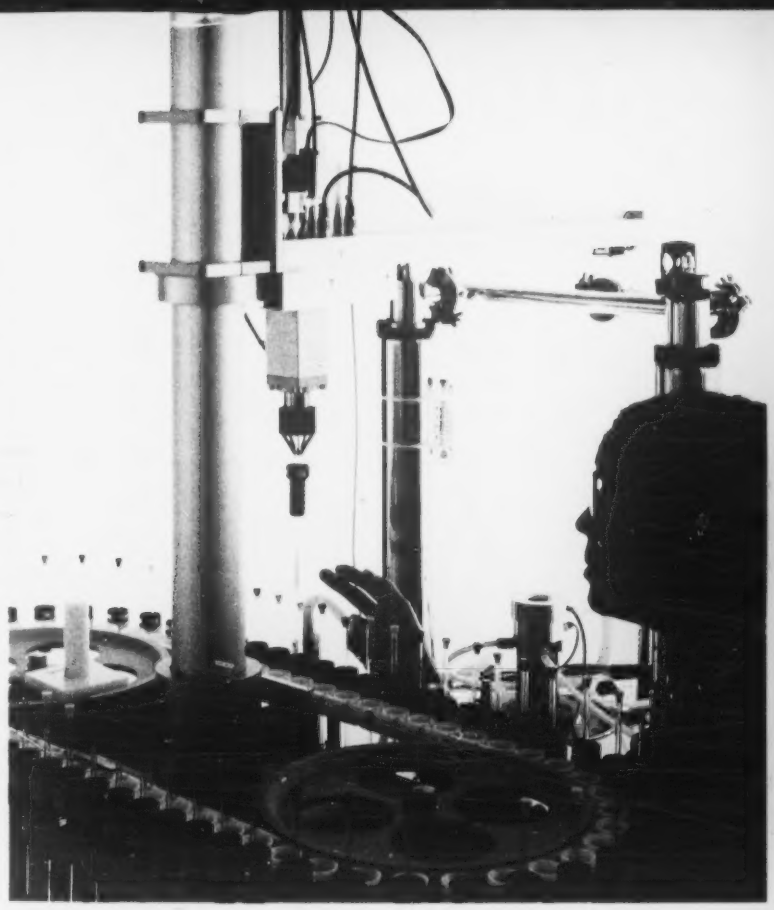
PPG Industries is leading a U.S.-Japanese-Indonesian venture that will produce caustic soda and chlorine, vinyl chloride, polyvinyl chloride, and other chlorinated chemicals in West Java. The $200 million venture already is on stream.

P. T. Arsento, a company of the Royal Dutch Shell group, is chipping in with a 300,000 metric-ton-per-year, $300 million polyethylene plant in Musi, West Java. And a consortium of four companies is building a polypropylene unit in Tangerang, also in West Java, that is due on stream late this year. Output will be used primarily for plastic bags and consumer goods.

Multinational joint ventures also are leading a surge in new aromatics capacity. One unit, on Sumatra, will produce 3.1 million metric tons of aromatics annually, all of it earmarked for the export market. And another $1.3 billion aromatics complex in Arun, North Sumatra, will produce benzene, toluene, mixed-xylenes, *o*-xylene, cyclohexane, and other aromatics intermediates.

Purified terephthalic acid and *p*-xylene plants also have been completed or are on the drawing boards for Indonesia. But the ever-present fear of overcapacity in Asia could compel Indonesia to reconsider some of its ambitious petrochemical projects.

Earl Anderson



Facts & Figures for Chemical R&D

Bette Hileman, C&EN Washington

The rate of growth in overall R&D funding this year has been sluggish. According to estimates made by the National Science Foundation, spending on R&D in the U.S. could reach $150 billion in 1990. That would be a 6% increase from funding in 1989—but only a 1% increase after adjusting for inflation.

Of the three major contributors to R&D—the federal government, industry, and universities—only universities are hiking R&D monies substantially in 1990: 7% after an adjustment for inflation. In real terms, industry funding at $74 billion and federal government funding at $69 billion are only 1% higher than the 1989 figures.

In the mid-1980s, total R&D spending was rising at 9 or 10% per year in constant dollars. But in the late 1980s, growth slowed to an annual rate of 3%, and in 1989 and 1990, it has almost come to a halt. Another way to look at it is that real R&D spending grew 40% between 1980 and 1985. Since then, the real gain has been only 11%.

The recent slowdown reflects, in part, sluggish growth in defense-related R&D. In 1977, only 23% of the total R&D funds were spent on defense. This share rose to 30% during the middle of the Reagan Administration and has held steady at 28% since 1987.

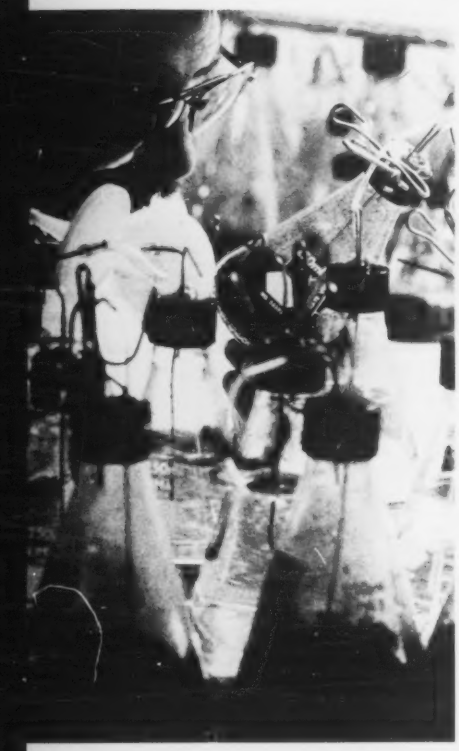
The share of the gross national product claimed by R&D in the U.S. has followed a similar pattern. It rose from a 20-year low of 2.1% in 1978 to 2.8% in 1985 and 1986, then fell to the current slightly lower figure of 2.7%. The share of GNP accounted for by nondefense R&D has remained steady at from 1.9 to 2.0% since 1983; its level is 1.9% this year.

Vast differences can be seen among the R&D efforts of different countries in terms of GNP used for R&D. Five countries—Sweden, Israel, Japan, Switzerland, and West Germany—spend a greater share of their GNP on R&D than the U.S. Hungary, France, the U.K., and the Netherlands spend from 2.2 to 2.6%, and a number of other countries with high-technology economies, such as South Korea, Norway, Italy, and Austria, spend only between 1.0 and 1.8%. Third World countries devote even smaller shares of their GNP to R&D.

Nevertheless, overall spending for R&D in the U.S. still dwarfs that of any other nation. In 1988, U.S. R&D funding was 2.6 times larger than Japan's, the next highest spender, and 5.7 times that in West Germany.

Even greater differences among countries can be seen when funds for defense R&D are considered. In 1988, Japan used only 1% of its total R&D funds for defense and West Germany used 2% for this purpose. The U.K. (24%) and France (23%) also spent smaller shares of their total R&D funds on defense than the U.S. In fact, the portion the U.S. used for defense (28%) was greater than that of any other nation for which data are available.

When the U.S. and Japan are compared on the basis of R&D performance, the U.S. comes out second



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best in many areas. For example, Japan's share of chemical literature abstracted by Chemical Abstracts Service has climbed steadily from 7.5% in 1973 to 11.8% in 1989, whereas the U.S.'s share crept up from 26.4% to 27.8%. In Japan, the number of R&D scientists and engineers has grown rapidly as a fraction of the total work force to 68.8 per 10,000 in 1987. In the U.S. their proportion is also rising, but more slowly. An indication of this is that in 1988 alone, the actual number of scientists and engineers in Japan increased 11%, whereas it grew only 3% in the U.S. In the U.S., however, the fraction of the work force employed in science and engineering—75.9 per 10,000—is still greater than it is in Japan or in any other country that NSF collects data for.

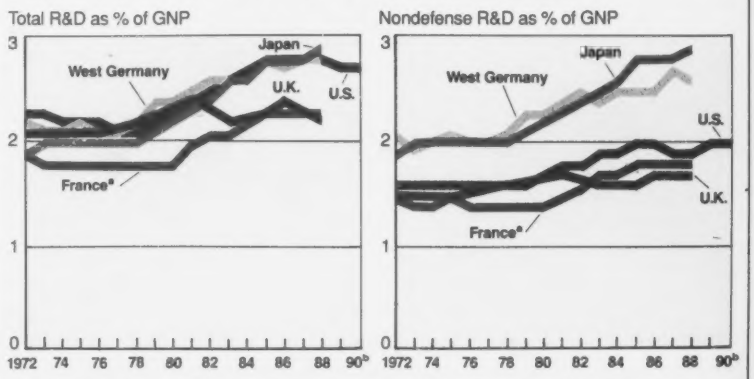
Japan's progress vis-à-vis the U.S. can be seen even more clearly in the number of chemical patents granted by the U.S. Patent & Trademark Office. The U.S. share of chemical patents granted to all recipients declined from 57% in 1980 to 51% in 1989; at the same time the portion granted to Japanese citizens, corporations, and government agencies rose from 12% to 20%. The shares of patents awarded to West Germany, the U.K., France, Switzerland, and Canada have remained fairly steady since 1980.

Another indication suggesting a decline in U.S. science and engineering relative to other countries is that the percent of foreign graduate students in all fields of science and engineering in the U.S. rose from 26% in 1983 to 32% in 1988. In chemistry, foreign graduate students represent 33% of the total.

Even more disturbing for the future of U.S. chemical R&D is the recent drop in the total number of graduate students in chemistry and chemical engineering (both foreign and U.S. students), which fell in 1988 for the first time in more than a decade. The number of B.S. and M.S. degrees granted in chemistry and chemical engineering also has fallen precipitously. Only the number of Ph.D. degrees increased, but that trend, too, probably will reverse itself in a few years because the graduate student population is declining.

The decrease in the number of graduate students in chemistry and chemical engineering is consistent with another, broader trend in the U.S. The total number of bachelor's degrees granted in science and engineering fell 9% between 1986 and 1988. For women science students, the decline was the first ever. So far,

R&D share of GNP similar in U.S., Japan, West Germany, but if defense excluded U.S. lags the other two



Note: 1989 percentages are C&EN estimates. **a** French data are based on gross domestic product, consequently percentages may be slightly overstated. **b** C&EN estimates. **Source:** National Science Foundation

the decline in the number of science and engineering students has not had any obvious effect on university funding for R&D, which has grown strongly in recent years.

Of the $150 billion total funding for R&D in the U.S. in 1990, $21.5 billion (14%) will be spent on basic research, $33.8 billion (23%) on applied research, and $94.7 billion (63%) on development. During the past decade, funding for basic research has risen at an annual rate of about 10%, and that for applied research and development has increased about 9% annually.

According to NSF estimates, the federal government provided $777 million for research in chemistry in the fiscal year that ended September 1989 (this excludes development)—a gain of 11% from the previous year. Most of the funds were contributed by four agencies: the departments of Energy, Defense, and Health & Human Services, and by NSF. Similarly, federal funds for chemical engineering research rose 12% to $290 million in 1989. The Energy Department continues to supply the largest amount of funds ($146 million) to chemical engineering research, and the Defense Department and NSF tie for second place, with about $40 million to $50 million each. Funds supplied by the federal government for chemistry and chemical engineering research, however, are only about 5% of the total government funding for all science and engineering research.

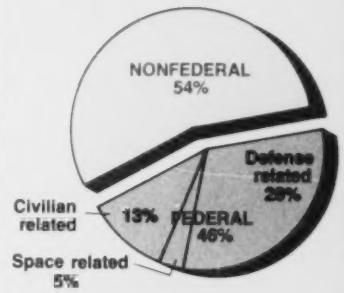
Universities also spent about 5% of their total science and engineering R&D outlays on chemistry and chemical engineering. More than half of these funds (in chemistry, 71%) are supplied by the federal government. In all, universities themselves and other nonfederal sources provided only $238 million for R&D in chemistry and chemical engineering at universities.

The chemical industry itself is the largest supporter of chemistry and chemical engineering research. The total funds for all industrial R&D edged above $100 billion last year, an increase of 4% over 1988, and of this, about 12%, or $11.9 billion (up 10%), was spent by the chemicals and allied products industry. Drug companies increased their R&D spending 14% to $5.4 billion in 1989 and helped boost the overall spending by all producers of chemicals and allied products.

Because about 70% of the R&D funds spent by the chemicals and allied products industry and about 3% of R&D funds spent by other industries goes for R&D in various aspects of chemical science and technology, industry probably spends about $10.9 billion in this area. When that is added to the $1.1 billion contributed by the federal government and the $200 million contributed by universities, the approximate total spent on R&D in chemistry and chemical engineering in the U.S. was about $12.2 billion in 1989. This was about 8% of the money that went into R&D in all fields of science and engineering.

Information for this Special Report is collected primarily from NSF's Division of Science Resources Studies, which publishes detailed statistical studies of most of the areas the report covers. These studies are available from the National Science Foundation, Division of Science Resources Studies, Office of the Director, 1800 G St., N.W., Washington, D.C. 20402, phone (202) 634-4634. □

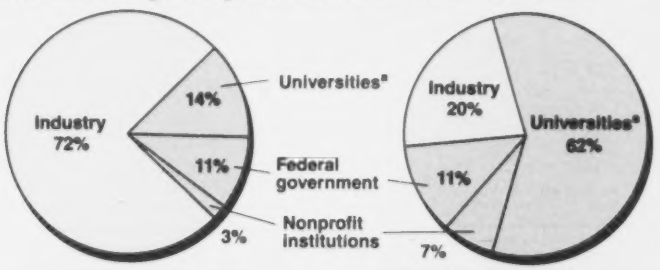
Defense takes more than a quarter of U.S. R&D funds



Estimated 1990 total R&D spending = $150 billion

Source: National Science Foundation

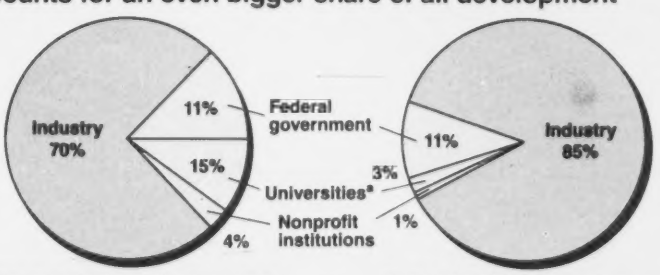
Only about a fourth of total R&D goes on in nonindustrial labs, even though they do 80% of basic research...



Estimated 1990 total R&D spending = $150 billion

Estimated 1990 basic research spending = $21 billion

...because industry performs 70% of applied research and accounts for an even bigger share of all development



Estimated 1990 applied research spending = $34 billion

Estimated 1989 development spending = $95 billion

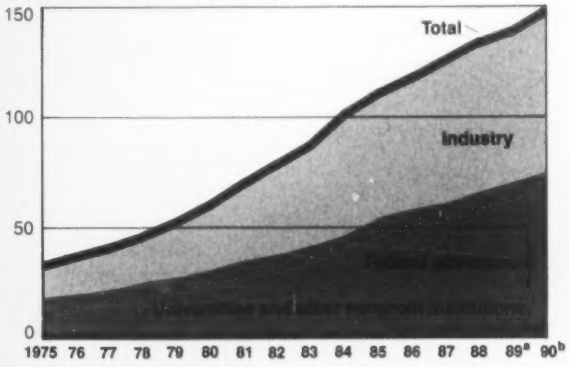
a Includes associated federally funded R&D centers. Source: National Science Foundation

1 R&D Overview

R&D Outlays Move Up to $150 Billion

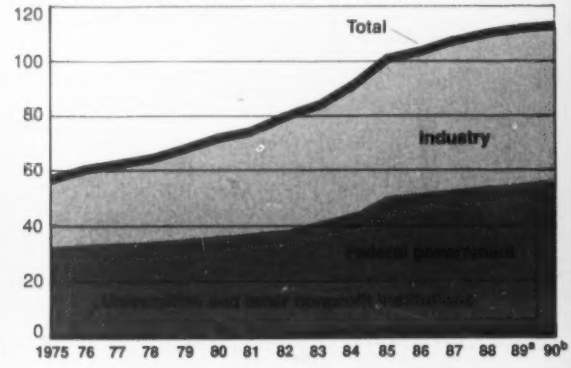
In current dollars, R&D spending rose more than 10% since 1988 . . .

Sources of R&D funds, $ billions, current



. . . but in real terms, it began to level off in the late 1980s

Sources of R&D funds, $ billions, constant (1982)



a Preliminary. b Estimated. **Source:** National Science Foundation

SOURCES OF R&D FUNDS: Almost all come from industry and government

$ Billions, current	1990[a]	1989[b]	1988	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978	Annual change 1987–88	Annual change 1978–88
Industry	$ 74.3	$ 70.4	$ 67.9	$ 64.1	$ 61.1	$ 58.0	$ 52.2	$ 45.3	$ 40.7	$ 35.9	$ 30.9	$ 26.1	$ 22.5	6%	12%
Federal government	69.2	65.9	62.1	58.5	54.6	52.1	45.6	40.8	36.6	33.4	29.5	26.8	23.9	6	10
Universities and colleges	4.3	3.9	3.4	3.1	2.8	2.4	2.1	1.9	1.7	1.5	1.3	1.2	1.0	10	13
Other nonprofit institutions	2.3	2.0	1.8	1.6	1.4	1.3	1.2	1.1	1.0	1.0	0.9	0.8	0.8	14	9
TOTAL	**$150.0**	**$142.0**	**$135.2**	**$127.3**	**$119.9**	**$113.7**	**$101.1**	**$ 89.1**	**$ 80.0**	**$ 71.9**	**$ 62.6**	**$ 54.9**	**$ 48.1**	**6%**	**11%**
ANNUAL CHANGE	**6%**	**5%**	**6%**	**6%**	**5%**	**12%**	**13%**	**11%**	**11%**	**15%**	**14%**	**14%**	**12%**		
$ Billions, constant 1982															
Industry	$ 56.4	$ 55.7	$ 55.9	$ 54.6	$ 53.7	$ 52.3	$ 48.5	$ 43.6	$ 40.7	$ 38.2	$ 36.1	$ 33.2	$ 31.1	2%	6%
Federal government	52.6	52.1	51.2	49.8	48.0	47.0	42.4	39.3	36.6	35.5	34.4	34.1	33.1	3	4
Universities and colleges	3.3	3.0	2.8	2.7	2.4	2.1	1.9	1.8	1.7	1.6	1.5	1.5	1.4	6	7
Other nonprofit institutions	1.7	1.5	1.5	1.4	1.2	1.2	1.1	1.1	1.0	1.0	1.1	1.1	1.1	-10	3
TOTAL	**$114.0**	**$112.4**	**$111.5**	**$108.4**	**$105.3**	**$102.6**	**$ 93.9**	**$ 85.8**	**$ 80.0**	**$ 76.4**	**$ 73.0**	**$ 69.9**	**$ 66.7**	**3%**	**5%**
ANNUAL CHANGE	**1%**	**1%**	**3%**	**3%**	**3%**	**9%**	**9%**	**7%**	**5%**	**5%**	**5%**	**5%**	**5%**		

Note: Constant-dollar values are calculated by C&EN based on NSF data. a NSF estimates. b Preliminary figures. **Source:** National Science Foundation

PERFORMERS OF R&D: Share done by academia has been increasing most rapidly recently

$ Billions, current	1990[a]	1989[b]	1988	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978	Annual change 1987–88	Annual change 1978–88
Industry	$108.2	$103.0	$ 99.4	$ 94.1	$ 88.2	$ 84.2	$ 74.8	$65.3	$58.7	$51.8	$44.5	$38.2	$33.3	6%	12%
Federal government	16.7	15.8	14.3	13.4	13.5	12.9	11.6	10.6	9.1	8.4	7.6	7.4	6.8	6	8
Universities and colleges	15.8	14.5	13.4	12.1	10.9	9.7	8.6	7.9	7.3	6.8	6.0	5.4	4.6	11	11
University-associated FFRDCs[c]	5.2	4.9	4.5	4.2	3.9	3.5	3.2	2.7	2.5	2.5	2.2	1.9	1.7	7	10
Other nonprofit institutions	4.1	3.9	3.6	3.5	3.4	3.4	3.0	2.7	2.4	2.3	2.2	2.0	1.7	2	8
TOTAL	**$150.0**	**$142.0**	**$135.2**	**$127.3**	**$119.9**	**$113.7**	**$101.1**	**$89.1**	**$80.0**	**$71.9**	**$62.6**	**$54.9**	**$48.1**	**6%**	**11%**
$ Billions, constant 1982															
Industry	$ 82.2	$ 81.6	$ 82.0	$ 80.2	$ 77.5	$ 75.9	$ 69.5	$62.8	$58.7	$55.1	$51.9	$48.6	$46.1	2%	6%
Federal government	12.7	12.5	11.8	11.4	11.9	11.7	10.7	10.2	9.1	9.0	8.9	9.4	9.4	3	2
Universities and colleges	12.0	11.4	11.1	10.3	9.6	8.7	8.0	7.6	7.3	7.3	7.1	6.8	6.4	8	6
University-associated FFRDCs[c]	4.0	3.8	3.7	3.6	3.4	3.2	2.9	2.6	2.5	2.6	2.6	2.5	2.4	4	5
Other nonprofit institutions	3.1	3.1	2.9	3.0	2.9	3.0	2.8	2.6	2.4	2.4	2.5	2.5	2.3	−1	2
TOTAL	**$114.0**	**$112.4**	**$111.5**	**$108.4**	**$105.4**	**$102.5**	**$ 93.9**	**$85.8**	**$80.0**	**$76.5**	**$73.0**	**$69.9**	**$66.7**	**3%**	**5%**

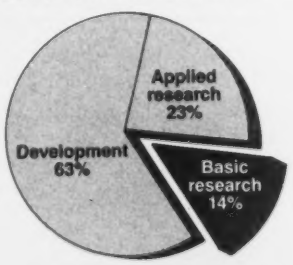
Note: Constant-dollar values are calculated by C&EN based on NSF data. a Estimated. b Preliminary. c Federally funded R&D centers. **Source:** National Science Foundation

U.S. CHEMICAL PATENTS: Total jumped by nearly a quarter last year

Number of patents issued	1989	1988	1987	1986	1985	1984	1983	1982	1981	1980	Total 1980–89
U.S. origin	**13,863**	**11,342**	**11,485**	**10,627**	**11,607**	**11,566**	**10,652**	**10,667**	**12,790**	**11,347**	**115,946**
to U.S. corporations	12,069	9,891	9,934	9,266	10,224	10,154	9,211	9,208	11,041	9,754	100,752
to U.S. government	327	300	366	326	322	378	331	312	367	366	3,395
to individuals in the U.S.	1,308	1,025	1,056	936	1,009	958	1,013	1,045	1,306	1,149	10,805
to foreign-owned corporations in the U.S.	159	126	129	99	52	76	97	102	76	78	994
Foreign origin	**13,172**	**10,575**	**10,284**	**9,135**	**9,717**	**9,030**	**8,110**	**8,038**	**9,660**	**8,387**	**96,108**
to U.S.-owned corporations abroad	1,131	854	854	760	885	839	705	733	904	823	8,488
to foreign corporations	11,139	8,963	8,673	7,698	8,104	7,463	6,746	6,532	7,882	6,790	79,990
to foreign governments	175	173	200	148	161	166	134	165	100	96	1,518
to foreign individuals	727	585	557	529	567	562	525	608	774	678	6,112
TOTAL	**27,035**	**21,917**	**21,769**	**19,762**	**21,324**	**20,596**	**18,762**	**18,705**	**22,450**	**19,734**	**212,054**
% FOREIGN	**48.7%**	**48.3%**	**47.2%**	**46.2%**	**45.6%**	**43.8%**	**43.2%**	**43.0%**	**43.0%**	**42.5%**	**45.3%**

Note: Includes patents issued in those technology subclasses that the U.S. Patent & Trademark Office classifies as chemical. **Source:** U.S. Patent & Trademark Office

Basic research gets only a seventh of R&D funds



Estimated total 1990 R&D spending = $150 billion

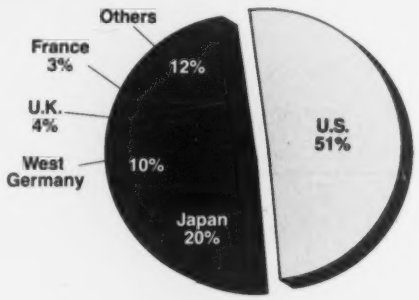
Source: National Science Foundation

RECIPIENTS OF U.S. CHEMICAL PATENTS: U.S.'s share continues steady decline

% of patents	1989	1988	1987	1986	1985	1984	1983	1982	1981	1980	Total 1980–89
U.S. origin	**51%**	**52%**	**53%**	**54%**	**54%**	**56%**	**57%**	**57%**	**57%**	**57%**	**55%**
Foreign origin[a]	**49**	**48**	**47**	**46**	**46**	**44**	**43**	**43**	**43**	**43**	**45**
Japan	20	20	19	19	18	16	15	14	13	12	17
West Germany	10	11	10	10	10	10	11	11	11	11	11
U.K.	4	4	4	4	4	4	4	4	4	5	4
France	3	4	4	3	3	3	3	4	4	4	3
Switzerland	2	2	2	2	2	2	2	2	2	3	2
Canada	2	2	1	1	2	1	1	1	1	1	1
Italy	2	1	1	1	1	1	1	1	1	2	1
Netherlands	1	1	1	1	1	1	1	1	1	1	1
Sweden	1	1	1	1	1	1	1	1	1	1	1
Belgium	1	1	1	1	1	1	1	1	1	1	1
U.S.S.R.	—	—	—	—	—	—	—	—	1	1	—

Note: Includes patents issued in those technology subclasses that the U.S. Patent & Trademark Office classifies as chemical. a Data for individual countries may not equal this number because of rounding. **Source:** U.S. Patent & Trademark Office

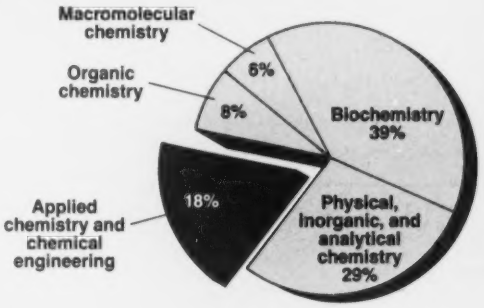
Almost half of U.S. chemical patents are of foreign origin



1989 total U.S. chemical patents issued = 27,035

Source: U.S. Patent & Trademark Office

Applied fields account for about a fifth of chemistry papers



1989 total[a] = 397,158

a Number of abstracts of papers published in *Chemical Abstracts*.
Source: Chemical Abstracts Service

PATENT ACTIVITY OF U.S. COMPANIES: Large gain for most chemical and drug firms

Number of patents issued	1989	1988	1987	1986	1985	1984	1983	1982	1981	1980	Total 1980–89
CHEMICAL COMPANIES											
Du Pont[a]	495	437	449	371	395	416	387	331	430	349	**4,060**
Dow Chemical	431	421	469	371	335	328	246	276	260	249	**3,386**
Ciba-Geigy	346	279	286	244	305	290	244	281	345	309	**2,929**
Union Carbide	132	141	159	208	242	231	182	202	262	211	**1,970**
American Cyanamid	114	101	107	92	115	111	128	129	188	205	**1,290**
PPG Industries	112	118	118	124	128	137	137	177	189	166	**1,406**
Dow Corning	105	82	58	68	55	52	37	35	50	31	**583**
Ethyl	87	51	48	77	105	76	44	31	43	51	**613**
Monsanto	87	76	91	110	100	138	136	131	211	205	**1,285**
Olin	80	59	58	81	117	112	85	80	80	106	**858**
GAF	50	23	15	12	23	19	21	32	47	48	**290**
Hercules	46	32	50	43	41	39	37	30	52	23	**393**
W. R. Grace	40	46	43	42	45	57	52	49	68	72	**514**
Stauffer Chemical	36	69	94	75	104	95	81	87	94	93	**828**
Rohm & Haas	32	18	22	33	31	37	55	49	77	74	**428**
International Flavors & Fragrances	31	24	38	76	104	95	87	87	96	76	**714**
TOTAL[b]	**2224**	**1977**	**2105**	**2027**	**2245**	**2233**	**1959**	**2007**	**2492**	**2268**	**21,537**
ANNUAL CHANGE	**12%**	**−6%**	**4%**	**−10%**	**1%**	**14%**	**−2%**	**−19%**	**10%**	**23%**	
DRUG COMPANIES											
Merck	173	125	123	103	105	135	114	135	160	156	**1,329**
Warner-Lambert	117	113	118	101	73	49	34	25	37	36	**703**
Hoffmann-LaRoche	93	59	86	84	74	78	90	118	124	144	**950**
Pfizer	79	63	67	72	72	89	61	72	92	75	**742**
American Home Products	76	69	46	38	49	32	24	43	52	52	**481**
Eli Lilly	75	68	85	82	107	80	74	104	112	85	**872**
Squibb	66	74	75	70	74	53	37	56	62	85	**652**
SmithKline Beckman	62	56	54	27	43	68	59	66	59	82	**576**
Upjohn	30	15	26	66	66	107	73	122	337	170	**1,012**
TOTAL[b]	**771**	**642**	**680**	**643**	**663**	**691**	**566**	**741**	**1035**	**885**	**7,317**
ANNUAL CHANGE	**20%**	**−6%**	**6%**	**−3%**	**−4%**	**22%**	**−24%**	**−28%**	**17%**	**5%**	

Note: Includes U.S. chemical and drug companies and U.S. subsidiaries of foreign companies that have received more than 1000 U.S. patents since 1962. a Includes patents issued to Conoco, acquired in 1981, for all years. b These totals include patents issued to companies in this table only. **Source:** U.S. Patent & Trademark Office

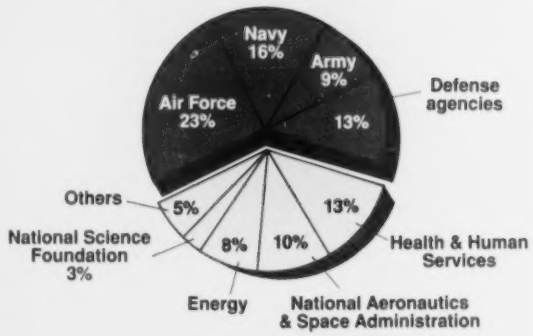
ABSTRACTS OF PAPERS IN *CHEMICAL ABSTRACTS*: Biochemistry's share holds at almost 40%

	1989	1988	1987	1986	1985	1984	1983	1979	Change 1979–89
BIOCHEMISTRY	39.2%	39.7%	40.5%	40.4%	40.5%	40.5%	38.3%	38.8%	0.4%
% of all biochemistry abstracts									
Pharmacology	12.6	12.7	12.6	12.2	12.3	11.6	11.8	11.9	0.7
Mammalian hormones[a]	12.0	12.0	12.2	12.5	12.3	12.4	12.9	5.9	6.1
Mammalian biochemistry[a]	10.7	10.8	11.1	10.8	11.1	11.3	11.1	17.1	−6.4
Biochemical genetics[b]	7.9	7.6	6.7	6.1	5.2	4.2	3.8	—	—
Toxicology	7.8	7.9	8.3	7.8	7.9	8.0	8.5	7.4	0.4
Immunochemistry	6.3	5.8	5.8	6.1	5.3	4.8	4.2	3.2	3.1
Enzymes	6.1	6.1	5.4	5.6	5.6	5.8	6.1	6.4	−0.3
Biochemical methods	5.1	5.1	4.8	5.0	4.9	4.9	4.9	5.4	−0.3
General biochemistry	5.1	5.3	4.6	4.7	4.9	5.3	5.8	7.0	−1.9
Microbial biochemistry[a]	5.1	4.8	5.1	5.7	5.7	5.2	5.1	5.3	−0.2
Plant biochemistry[a]	4.6	5.0	5.3	5.2	5.5	6.2	5.9	5.8	−1.2
Others	16.7	16.9	18.1	18.3	19.3	20.3	19.9	24.6	−7.9
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	—
PHYSICAL, INORGANIC, AND ANALYTICAL CHEMISTRY	29.0%	28.8%	29.0%	29.8%	29.8%	28.8%	29.6%	28.9%	0.1%
% of all physical, inorganic, and analytical chemistry abstracts									
Nuclear chemistry	19.4	17.8	19.5	19.9	21.8	22.2	22.5	25.1	−5.7
Spectra	18.1	20.0	20.4	20.0	18.4	18.0	17.6	17.0	1.1
Electric phenomena	13.9	12.5	10.9	10.8	10.8	10.8	10.0	11.4	2.5
Crystallography and liquid crystals	7.8	7.0	7.1	7.0	7.5	7.8	8.3	8.2	−0.4
General physical chemistry	6.9	7.2	7.9	7.0	6.9	6.9	7.3	6.6	0.3
Analytical chemistry	5.1	5.7	5.9	6.8	6.1	6.3	6.2	5.6	−0.5
Others	28.8	29.8	28.3	28.5	28.5	28.0	28.1	25.8	3.0
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	—
APPLIED CHEMISTRY AND CHEMICAL ENGINEERING	18.1%	18.6%	18.0%	18.2%	18.4%	17.6%	19.4%	19.4%	−1.3%
% of all applied chemistry and chemical engineering abstracts									
Metals and alloys	22.1	21.7	20.6	20.8	20.0	18.9	19.1	23.6	−1.5
Water, wastes, and pollution	17.8	20.4	20.4	21.9	20.2	21.0	19.6	20.8	−3.0
Unit operations and processes	10.3	8.0	9.0	7.1	7.5	7.0	7.5	6.1	4.2
Mineralogical and geological chemistry	9.3	11.8	11.2	12.0	12.5	14.6	14.1	15.8	−6.5
Ceramics	9.1	6.7	6.3	5.8	5.6	5.1	5.4	5.0	4.1
Fossil fuels, derivatives, and related products	8.7	8.8	9.6	9.0	10.1	10.1	10.3	7.8	0.9
Pharmaceuticals and pharmaceutical analysis	7.8	7.6	7.8	8.2	8.0	7.0	6.5	5.1	2.7
Others	14.9	15.0	15.1	15.2	16.1	16.3	17.5	15.8	−0.9
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	—
ORGANIC CHEMISTRY	7.8%	7.3%	6.9%	5.9%	6.4%	7.6%	7.3%	7.6%	0.2%
% of all organic chemistry abstracts									
Physical organic chemistry	25.9	23.0	23.9	27.3	30.6	32.0	30.5	38.8	−12.9
Organometallic and organometalloidal compounds	18.4	15.7	16.1	18.3	16.2	17.1	16.3	8.5	9.9
Heterocyclic compounds[a]	16.1	18.8	19.9	15.0	16.1	15.6	16.2	16.0	0.1
Aromatic compounds[a]	6.9	7.2	7.7	7.3	6.3	6.3	7.1	8.2	−1.3
Carbohydrates	6.5	6.1	5.6	7.8	5.7	5.7	5.8	6.0	0.5
Biomolecules and their synthetic analogs[b]	5.8	6.1	5.8	5.0	4.9	4.4	4.5	—	—
Amino acids, peptides, and proteins[a]	4.5	5.8	4.3	3.9	4.6	4.8	4.5	4.1	0.4
Aliphatic compounds[a]	3.6	4.1	4.9	4.4	4.2	3.6	4.3	6.0	−2.4
Others	12.3	11.2	11.8	11.0	11.4	10.5	10.8	12.4	−0.1
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	—
MACROMOLECULAR CHEMISTRY	5.9%	5.6%	5.6%	5.7%	4.9%	5.5%	5.4%	5.3%	0.6%
% of all macromolecular chemistry abstracts									
Synthetic high polymers	34.4	34.8	35.2	34.1	34.1	34.0	34.4	26.3	8.1
Plastics manufacture and uses	25.1	23.7	23.6	23.8	25.3	24.2	24.4	27.8	−2.7
Cellulose, lignin, paper, and other wood products	9.2	9.6	8.8	9.8	9.1	9.6	9.1	11.1	−1.9
Textiles	7.2	7.3	8.1	8.8	8.2	7.3	7.9	10.1	−2.9
Synthetic elastomers and natural rubber	5.6	6.7	7.2	6.7	6.8	7.3	7.5	7.6	−2.0
Coatings, inks, and related products	5.6	5.7	5.8	7.2	7.2	7.8	6.6	8.1	−2.5
Others	12.9	12.2	11.3	9.6	9.3	9.8	10.1	9.0	3.9
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	—

How to read this table: Using biochemistry as an example, in 1989 39.2% of all the papers abstracted by Chemical Abstracts Service are in the various subdisciplines of biochemistry; 12.6% of all abstracts in biochemistry, in turn, are in the subdiscipline of pharmacology, and so on. a Definition of section changed in 1982. b New section in 1982. **Source:** Chemical Abstracts Service

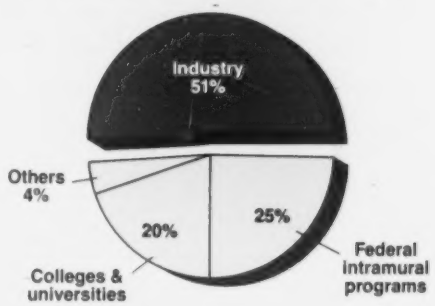
Bulk of Federal Funds Still Go to Defense

Defense Department contributes more than 60% of federal R&D funding...



Estimated fiscal 1990 total federal R&D obligations = $66.1 billion

...with industrial firms receiving about half of total federal spending



Estimated fiscal 1990 total federal R&D obligations = $66.1 billion

Source: National Science Foundation

FEDERAL OBLIGATIONS FOR R&D: Growth on hold for Energy, Agriculture, Interior, and Commerce

$ Millions	1990[a]	1989[a]	1988	1987	1986	1985	1984	1983	Annual change 1987–88	Annual change 1983–88
Defense	**$40,242**	**$37,630**	**$35,415**	**$35,232**	**$32,938**	**$29,792**	**$25,373**	**$22,993**	1%	9%
Air Force	15,069	15,266	15,034	15,348	13,594	13,261	12,092	10,813	−2	7
Navy	10,373	9,618	9,514	9,508	9,650	9,127	7,606	6,068	0	9
Army	5,843	5,351	4,806	5,020	4,809	4,571	4,226	3,998	−4	4
Defense agencies	8,538	7,189	5,833	5,220	4,767	2,782	1,392	2,052	12	23
Health & Human Services	**8,376**	**7,888**	**7,158**	**6,609**	**5,658**	**5,451**	**4,831**	**4,353**	**8**	**10**
National Institutes of Health	7,177	6,792	6,291	5,853	5,005	4,828	4,257	3,789	7	11
Alcohol, Drug Abuse & Mental Health Administration	764	679	555	476	396	378	337	302	17	13
National Aeronautics & Space Administration	**6,870**	**5,688**	**4,330**	**3,787**	**3,420**	**3,327**	**2,822**	**2,662**	**14**	**10**
Energy	**5,282**	**5,479**	**5,036**	**4,757**	**4,688**	**4,996**	**4,674**	**4,537**	**6**	**2**
National Science Foundation	**1,881**	**1,664**	**1,532**	**1,471**	**1,353**	**1,346**	**1,203**	**1,062**	**4**	**8**
Agriculture	**1,045**	**1,049**	**1,017**	**948**	**929**	**943**	**866**	**848**	**7**	**4**
Agricultural Research Service	546	525	506	479	463	470	451	443	6	3
Cooperative State Research Service	279	308	298	271	269	284	236	232	10	5
Forest Service	143	138	136	127	113	113	108	108	7	5
Environmental Protection Agency	**421**	**386**	**347**	**348**	**317**	**320**	**261**	**241**	**0**	**8**
Interior	**388**	**432**	**417**	**404**	**385**	**392**	**411**	**383**	**3**	**2**
Geological Survey[b]	231	240	236	227	219	215	209	157	4	8
Commerce	**310**	**406**	**389**	**402**	**399**	**399**	**358**	**335**	**−3**	**3**
National Oceanic & Atmospheric Administration	178	268	263	286	275	270	244	222	−8	3
National Institute of Standards & Technology	118	123	108	99	101	101	96	95	9	3
Others	**1,269**	**1,157**	**1,186**	**1,298**	**1,325**	**1,367**	**1,427**	**1,300**	**−9**	**−2**
TOTAL	**$66,084**	**$61,902**	**$56,935**	**$55,255**	**$51,412**	**$48,332**	**$42,225**	**$38,712**	**3%**	**8%**
ANNUAL CHANGE	**7%**	**9%**	**3%**	**7%**	**6%**	**14%**	**9%**	**6%**		

Note: Fiscal years. a Estimated. b Includes Office of Water Research & Technology. Source: National Science Foundation

PERFORMERS OF FEDERALLY FUNDED R&D: Academia accounts for about a fifth of the total

Federal obligations, $ millions	1990[a]	1989[a]	1988	1987	1986	1985	1984	1983	Annual change 1987–88	Annual change 1983–88
Industry	**$33,401**	**$31,051**	**$28,631**	**$28,628**	**$25,898**	**$23,496**	**$20,219**	**$18,521**	**0%**	**16%**
FFRDCs[b] administered by industry	2,071	2,008	1,911	1,860	1,697	1,791	1,608	1,501	3	5
Federal intramural Programs	**16,726**	**15,795**	**14,281**	**13,413**	**13,535**	**12,945**	**11,572**	**10,582**	**6**	**6**
Universities and colleges	**12,977**	**12,026**	**11,302**	**10,545**	**9,327**	**9,156**	**8,033**	**7,360**	**7**	**9**
FFRDCs[b] administered by universities	4,151	3,740	3,474	3,210	2,768	2,816	2,486	2,394	8	8
Nonprofit institutions	**2,412**	**2,501**	**2,188**	**2,221**	**2,228**	**2,388**	**2,094**	**1,823**	**−1**	**4**
FFRDCs[b] administered by nonprofit institutions	556	593	506	511	551	689	597	581	−1	−3
Foreign	**409**	**362**	**392**	**295**	**296**	**245**	**176**	**240**	**33**	**10**
State and local governments	**160**	**167**	**142**	**148**	**128**	**129**	**131**	**186**	**−4**	**−5**
TOTAL	**$66,084**	**$61,902**	**$56,935**	**$55,253**	**$51,412**	**$48,360**	**$42,225**	**$36,432**	**3%**	**9%**

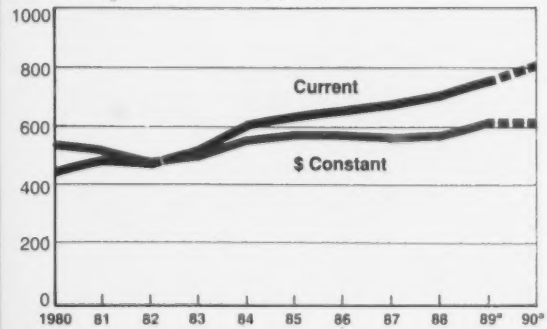
Note: Fiscal years. a Estimated. b Federally funded R&D centers. **Source:** National Science Foundation

FEDERAL OBLIGATIONS FOR SCIENTIFIC DISCIPLINES: Engineering, environmental science slow

$ Millions for research only	1990[a]	1989[a]	1988	1987	1986	1985	1984	1983	Annual change 1987–88	Annual change 1983–88
Life sciences	**$ 8,739**	**$ 8,276**	**$ 7,724**	**$ 7,344**	**$ 6,464**	**$ 6,366**	**$ 5,636**	**$ 5,178**	**5%**	**8%**
Engineering	**4,258**	**4,364**	**3,956**	**3,906**	**3,739**	**3,629**	**3,624**	**3,517**	**1**	**2**
Chemical	229	290	258	216	246	254	145	145	19	12
Metallurgy and materials	456	510	457	362	445	439	341	333	12	7
National engineering centers	656	721	678	669	632	664	858	828	6	−4
Physical sciences	**3,966**	**3,726**	**3,317**	**3,253**	**3,069**	**3,044**	**2,969**	**2,891**	**12**	**3**
Chemistry	808	777	703	680	662	645	606	520	11	6
Physics	2,314	2,185	1,975	1,854	1,806	1,820	1,836	1,855	6	1
Environmental sciences	**1,756**	**1,774**	**1,607**	**1,512**	**1,482**	**1,404**	**1,276**	**1,251**	**6**	**5**
Mathematical and computer sciences	**755**	**724**	**643**	**641**	**615**	**578**	**440**	**419**	**0**	**9**
Other sciences	**1,617**	**1,551**	**1,402**	**1,288**	**1,133**	**1,110**	**1,034**	**997**	**9**	**7**
TOTAL	**$21,091**	**$20,415**	**$18,649**	**$17,943**	**$16,502**	**$16,130**	**$14,979**	**$14,254**	**4%**	**6%**
ANNUAL CHANGE	**3%**	**9%**	**4%**	**9%**	**2%**	**8%**	**5%**	**9%**		

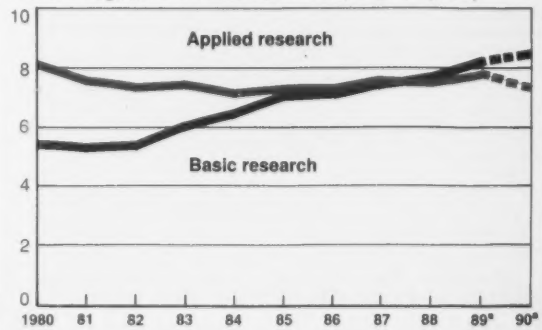
Note: Fiscal years. a Estimated. **Source:** National Science Foundation

In real dollars, federal support for chemical research changed little during 1980s



Note: Fiscal years. Constant-dollar values calculated by C&EN based on NSF data. a Estimated. **Source:** National Science Foundation

Funding for applied research has stalled but that for basic research climbs steadily



Note: Fiscal years. Constant-dollar values calculated by C&EN based on NSF data. a Estimated. **Source:** National Science Foundation

FEDERAL OBLIGATIONS FOR BASIC RESEARCH: Health research takes more than 40%

$ Millions	1990[a]	1989[a]	1988	1987	1986	1985	1984	1983	Annual change 1987–88	Annual change 1983–88
Health & Human Services	**$ 4,754**	**$ 4,411**	**$4081**	**$3830**	**$3339**	**$3233**	**$2815**	**$2475**	**7%**	**11%**
National Institutes of Health	4,347	4,063	3795	3577	3119	3018	2625	2313	7	10
Alcohol, Drug Abuse & Mental Health Administration	360	321	266	232	203	197	171	145	15	13
National Science Foundation	**1,754**	**1,553**	**1433**	**1371**	**1275**	**1262**	**1132**	**999**	**5**	**7**
National Aeronautics & Space Administration	**1,462**	**1,438**	**1113**	**1014**	**917**	**751**	**755**	**617**	**10**	**13**
Energy	**1,394**	**1,314**	**1185**	**1069**	**960**	**943**	**830**	**768**	**12**	**9**
Defense	**964**	**908**	**877**	**908**	**924**	**861**	**848**	**786**	**−3**	**2**
Navy	390	344	342	354	337	343	316	305	−3	2
Air Force	216	188	196	222	216	198	192	164	−12	4
Army	207	175	166	217	248	241	222	208	−24	−4
Defense agencies	151	201	173	115	122	79	118	108	50	10
Agriculture	**512**	**491**	**481**	**446**	**433**	**445**	**393**	**382**	**8**	**6**
Agricultural Research Service	295	283	271	253	248	250	241	215	7	5
Cooperative State Research Service	153	145	146	133	132	142	100	99	10	8
Forest Service	54	52	52	49	42	44	41	39	6	6
Interior	**129**	**147**	**126**	**135**	**133**	**138**	**126**	**103**	**−7**	**4**
Geological Survey[b]	92	94	90	85	83	81	79	65	6	7
Bureau of Mines	32	48	32	46	45	50	41	24	−30	6
Environmental Protection Agency	**76**	**44**	**27**	**31**	**39**	**39**	**30**	**22**	**−13**	**4**
Commerce	**31**	**32**	**31**	**26**	**27**	**23**	**21**	**19**	**19**	**10**
National Institute of Standards & Technology	27	28	26	25	26	22	20	18	4	8
Others	**125**	**126**	**120**	**116**	**107**	**124**	**119**	**109**	**3**	**2**
TOTAL	**$11,201**	**$10,464**	**$9474**	**$8944**	**$8153**	**$7819**	**$7067**	**$6260**	**6%**	**9%**
ANNUAL CHANGE	**7%**	**10%**	**6%**	**10%**	**4%**	**11%**	**13%**	**14%**		

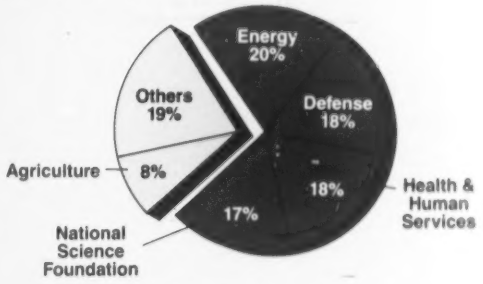
Note: Fiscal years. a Estimated. Includes Office of Water Research & Technology. **Source:** National Science Foundation

FEDERAL OBLIGATIONS FOR APPLIED RESEARCH: Health outlays edge above those for military

$ Millions	1990[a]	1989[a]	1988	1987	1986	1985	1984	1983	Annual change 1987–88	Annual change 1983–88
Health & Human Services	**$ 2796**	**$2694**	**$2416**	**$2195**	**$1851**	**$1796**	**$1652**	**$1545**	**10%**	**9%**
National Institutes of Health	2106	2046	1886	1740	1469	1410	1286	1165	8	10
Alcohol, Drug Abuse & Mental Health Administration	400	355	287	241	192	180	165	155	19	13
Defense	**2412**	**2527**	**2362**	**2440**	**2303**	**2307**	**2201**	**2437**	**−3**	**−1**
Army	590	582	588	693	579	583	487	485	−15	4
Air Force	581	550	577	563	542	538	548	524	2	2
Navy	411	417	406	432	447	448	450	522	−6	−5
Defense agencies	829	978	791	751	735	738	717	906	5	−3
National Aeronautics & Space Administration	**1584**	**1426**	**1219**	**1256**	**1152**	**1033**	**955**	**928**	**−3**	**6**
Energy	**1000**	**1105**	**1051**	**1029**	**1081**	**1198**	**1195**	**1193**	**2**	**−3**
Agriculture	**501**	**526**	**505**	**473**	**464**	**466**	**442**	**456**	**7**	**2**
Agricultural Research Service	224	215	208	201	188	192	184	203	3	0
Cooperative State Research Service	127	163	153	138	137	143	136	134	11	3
Forest Service	84	81	80	73	68	66	64	65	10	4
Environmental Protection Agency	**262**	**259**	**241**	**246**	**179**	**176**	**142**	**152**	**−2**	**10**
Commerce	**247**	**326**	**311**	**313**	**313**	**301**	**276**	**266**	**−1**	**3**
National Oceanic & Atmospheric Administration	158	234	225	234	237	224	198	189	−4	4
National Institute of Standards & Technology	80	82	73	64	63	65	64	63	14	3
Interior	**237**	**259**	**266**	**247**	**235**	**231**	**254**	**255**	**8**	**1**
Geological Survey[b]	127	133	136	132	128	130	125	90	3	9
National Science Foundation	**127**	**110**	**100**	**99**	**78**	**84**	**71**	**63**	**1**	**10**
Others	**725**	**719**	**705**	**700**	**693**	**720**	**725**	**699**	**1**	**0**
TOTAL	**$ 9891**	**$9951**	**$9176**	**$8999**	**$8349**	**$8312**	**$7911**	**$7993**	**2%**	**3%**
ANNUAL CHANGE	**−1%**	**8%**	**2%**	**8%**	**0%**	**5%**	**−1%**	**6%**		

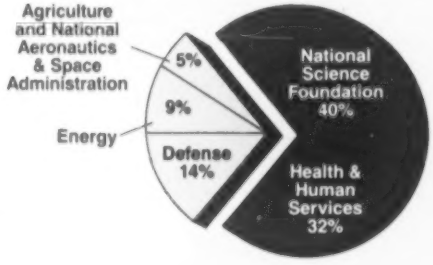
Note: Fiscal years. a Estimated. b Includes Office of Water Research & Technology. **Source:** National Science Foundation

Four agencies dominate government funding for chemical research...



Estimated fiscal 1990 federal chemistry research obligations = $808 million

...but at universities, NSF and HHS alone provide most of the money



Estimated fiscal 1990 federal chemistry university research obligations = $324 million[a]

a Total is for these six agencies only. **Source:** National Science Foundation

UNIVERSITY RESEARCH: Life sciences continue to garner most government support

Federal obligations, $ millions	1990	1989[a]	1988[a]	1987	1986	1985	1984	1983	Annual change 1987–88	Annual change 1983–88
Life sciences	$4595	$4227	$4029	$3824	$3252	$3192	$2800	$2460	5%	10%
Physical sciences	985	918	857	823	752	750	698	597	4	8
Chemistry	324	310	295	281	266	267	242	206	5	7
Physics	497	461	425	404	405	402	375	329	5	5
Engineering	751	700	673	600	609	507	474	409	12	10
Chemical	56	66	57	55	51	46	51	24	4	19
Metallurgy and materials	181	158	175	108	133	107	88	86	62	15
Environmental sciences	474	449	408	400	366	361	320	317	2	5
Mathematical and computer sciences	385	357	305	289	274	253	182	172	6	12
Other sciences	603	559	494	449	385	348	304	298	10	11
TOTAL	$7793	$7210	$6766	$6384	$5617	$5411	$4777	$4252	8%	10%
ANNUAL CHANGE	8%	7%	6%	14%	4%	13%	12%	12%		

Note: Fiscal years. Includes funding only from six agencies that together represent approximately 97% of federal research support to universities. a Estimated. **Source:** National Science Foundation

UNIVERSITY RESEARCH IN CHEMISTRY: NSF, NIH, and DOD provide 85% of total

Federal obligations, $ millions	1990[a]	1989[a]	1988	1987	1986	1985	1984	1983	Annual change 1987–88	Annual change 1983–88
National Science Foundation	$128.4	$117.8	$111.6	$107.1	$103.5	$108.1	$100.7	$ 84.7	4%	6%
Health & Human Services	104.9	95.7	91.4	85.0	75.0	75.2	63.2	51.9	8	12
National Institutes of Health	102.1	93.2	89.3	83.4	74.4	74.7	62.8	51.4	7	12
Alcohol, Drug Abuse & Mental Health Administration	2.7	2.4	2.1	1.6	0.6	0.6	0.4	0.5	31	33
Defense	44.4	42.8	41.3	45.0	43.2	40.4	34.7	29.1	−8	7
Air Force	18.5	16.3	17.0	18.4	16.1	14.0	na	9.6	−8	12
Navy	16.0	13.9	13.6	17.2	13.9	15.5	na	11.7	−21	3
Army	8.7	8.2	8.8	8.3	12.4	10.9	na	7.8	6	2
Defense agencies	1.2	4.4	1.8	1.1	0.9	0	na	0	64	0
Energy	29.5	36.5	33.8	28.5	27.6	26.0	26.3	18.6	19	13
Agriculture	10.7	12.3	11.8	11.2	12.2	15.5	13.5	14.5	5	−4
National Aeronautics & Space Administration	5.9	5.1	4.8	4.3	4.2	4.1	4.1	4.6	12	1
TOTAL	$323.7	$310.3	$294.7	$281.1	$265.7	$269.4	$242.3	$205.7	5%	7%
ANNUAL CHANGE	4%	5%	5%	6%	−1%	11%	18%	na		

Note: Fiscal years. Data from these six agencies represent approximately 97% of federal obligations for 1990. a Estimated. na = not available. **Source:** National Science Foundation

FEDERAL OBLIGATIONS FOR DEVELOPMENT: Vast majority of outlays still go to defense

$ Millions	1990[a]	1989[a]	1988	1987	1986	1985	1984	1983	Annual change 1987–88	Annual change 1983–88
Defense	**$36,866**	**$34,195**	**$32,176**	**$31,884**	**$29,711**	**$26,623**	**$22,324**	**$19,770**	**1%**	**10%**
Air Force	14,272	14,528	14,261	14,563	12,835	12,524	11,352	10,124	−2	7
Navy	9,571	8,856	8,766	8,721	8,866	8,336	6,840	5,241	1	11
Army	5,045	4,594	4,052	4,110	3,982	3,747	3,517	3,305	−1	4
Defense agencies	7,558	6,010	4,868	4,354	3,911	1,965	557	1,039	12	36
National Aeronautics & Space Administration	**3,824**	**2,824**	**1,999**	**1,518**	**1,351**	**1,544**	**1,113**	**1,117**	**32**	**12**
Energy	**2,888**	**3,060**	**2,801**	**2,659**	**2,648**	**2,825**	**2,649**	**2,576**	**5**	**2**
Health & Human Services	**826**	**783**	**661**	**584**	**468**	**423**	**365**	**332**	**13**	**15**
National Institutes of Health	725	682	610	536	418	400	347	311	13	14
Environmental Protection Agency	**82**	**82**	**80**	**71**	**100**	**106**	**89**	**66**	**13**	**17**
Commerce	**37**	**47**	**47**	**64**	**60**	**75**	**62**	**50**	**−26**	**−1**
National Oceanic & Atmospheric Administration	17	31	35	52	37	45	47	33	−33	1
National Institute of Standards & Technology	12	14	9	9	12	14	12	14	0	−8
Agriculture	**32**	**31**	**31**	**29**	**32**	**32**	**31**	**10**	**7**	**25**
Agricultural Research Service	27	26	26	24	27	28	27	26	8	0
Interior	**22**	**26**	**24**	**22**	**17**	**22**	**31**	**25**	**9**	**−1**
Geological Survey[b]	13	13	11	10	7	4	5	2	10	41
National Science Foundation	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Others	**416**	**439**	**466**	**482**	**524**	**553**	**583**	**493**	**−3**	**−1**
TOTAL	**$44,993**	**$41,487**	**$38,285**	**$37,313**	**$34,910**	**$32,202**	**$27,246**	**$24,458**	**2%**	**9%**
ANNUAL CHANGE	**8%**	**8%**	**3%**	**7%**	**8%**	**18%**	**11%**	**4%**		

Note: Fiscal years. a Estimated. b Includes Office of Water Research & Technology. **Source:** National Science Foundation

ENGINEERING RESEARCH: Overall government support is declining slightly in 1990, but for

Federal obligations, $ millions	1990[a] All engineering	1990[a] Chemical engineering	1990[a] Metallurgy & materials	1989[a] All engineering	1989[a] Chemical engineering	1989[a] Metallurgy & materials	1988 All engineering	1988 Chemical engineering
Defense	**$1599.9**	**$ 49.2**	**$285.0**	**$1729.0**	**$ 47.5**	**$331.0**	**$1636.1**	**$ 41.9**
Air Force	466.4	3.3	42.9	434.6	3.2	38.8	455.1	1.8
Army	400.4	24.4	27.1	367.2	23.7	23.9	384.4	20.3
Navy	391.5	20.8	54.8	375.4	18.9	51.9	379.8	19.6
Defense agencies	341.5	0.7	160.1	551.7	1.7	216.2	416.8	0.1
National Aeronautics & Space Administration	**1485.7**	**2.3**	**25.2**	**1362.4**	**1.9**	**22.4**	**1138.2**	**2.0**
Energy	**377.3**	**74.2**	**78.2**	**500.0**	**145.5**	**78.8**	**479.5**	**134.5**
National Science Foundation	**268.1**	**49.6**	**30.5**	**231.9**	**42.4**	**28.1**	**206.8**	**38.9**
Transportation	**78.8**	**5.2**	**0.7**	**81.2**	**7.4**	**0.3**	**71.9**	**1.0**
Interior	**73.2**	**4.7**	**23.6**	**97.3**	**4.9**	**35.1**	**85.3**	**5.1**
Environmental Protection Agency	**58.4**	**28.9**	**0.9**	**57.3**	**29.2**	**1.3**	**50.7**	**24.2**
Commerce	**49.7**	**5.9**	**12.4**	**55.8**	**3.5**	**12.5**	**49.3**	**2.7**
Agriculture	**32.4**	**8.1**	**0**	**32.1**	**7.8**	**0**	**31.7**	**7.7**
Others	**234.3**	**0**	**0**	**216.7**	**0.1**	**0**	**206.7**	**0.1**
TOTAL	**$4257.8**	**$229.1**	**$456.5**	**$4363.7**	**$290.2**	**$509.5**	**$3956.2**	**$258.1**
ANNUAL CHANGE	**−2%**	**−21.1%**	**−10%**	**10%**	**12%**	**11%**	**1%**	**20%**

Note: Fiscal years. a Estimated. **Source:** National Science Foundation

FEDERAL OBLIGATIONS FOR CHEMICAL RESEARCH: Increases have been moderate since 1985

$ Millions	1990[a]	1989[a]	1988	1987	1986	1985	1984	1983	Annual change 1987–88	Annual change 1983–88
Energy	$165.2	$171.8	$162.9	$145.5	$145.9	$143.0	$140.4	$117.6	12%	7%
Defense	146.2	125.2	125.0	144.9	163.4	156.4	139.8	121.8	−13	1
Army	71.7	55.4	57.5	72.2	81.4	78.2	66.3	59.3	−20	−1
Air Force	46.2	41.7	43.6	43.3	42.0	39.5	36.7	31.2	1	7
Navy	27.1	23.7	22.1	28.4	39.1	38.3	36.6	31.1	−22	−7
Defense agencies	1.2	4.4	1.8	1.1	0.9	0.4	0.3	0.3	64	43
Health & Human Services	143.9	134.9	123.8	115.5	104.2	99.1	86.3	74.2	7	11
National Institutes of Health	130.3	122.8	114.4	108.1	99.5	95.1	84.1	72.2	6	10
Alcohol, Drug Abuse & Mental Health Administration	13.7	12.1	9.4	7.4	4.7	4.0	2.3	2.0	27	36
National Science Foundation	139.3	126.8	120.6	115.3	112.6	115.6	109.9	92.4	5	0
Agriculture	61.2	60.9	60.8	65.0	58.6	58.0	69.0	63.8	−6	−1
Agricultural Research Service	42.1	40.5	40.9	46.4	40.0	36.1	51.6	49.5	−11	−4
Cooperative State Research Service	11.1	12.7	12.2	11.5	12.4	16.1	13.5	10.8	6	2
Forest Service	8.0	7.8	7.6	7.1	6.2	5.7	3.9	3.6	7	16
National Aeronautics & Space Administration	50.1	56.6	27.5	13.4	11.8	16.3	7.3	9.4	105	24
Environmental Protection Agency	42.7	36.5	30.6	34.6	20.1	17.5	15.9	14.8	−12	16
Commerce	24.6	24.8	23.6	22.9	19.1	17.7	15.3	14.0	3	11
National Institute of Standards & Technology	18.6	18.1	16.9	16.5	16.4	15.4	14.1	12.7	2	6
National Oceanic & Atmospheric Administration	6.0	6.7	6.7	6.4	2.4	1.4	1.3	1.2	5	41
Interior	21.4	22.2	21.9	20.9	20.3	19.4	19.2	6.2	5	29
Geological Survey[b]	20.9	21.9	21.7	20.8	20.2	19.4	18.4	5.6	4	31
Others	13.3	17.6	6.4	2.4	6.3	1.5	3.3	6.1	167	1
TOTAL	$807.9	$777.3	$703.1	$680.3	$662.4	$644.5	$606.4	$520.3	3%	6%
ANNUAL CHANGE	4%	11%	3%	3%	3%	6%	17%	8%		

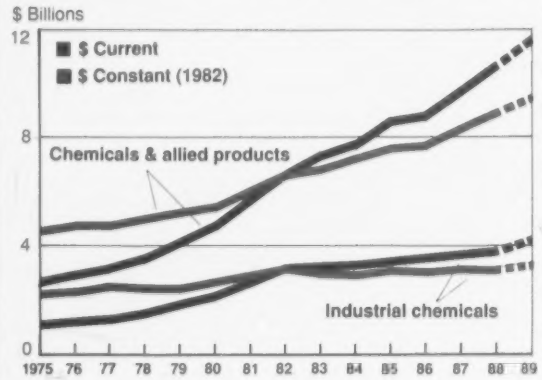
Note: Fiscal years. a Estimated. b Includes Office of Water Research & Technology. **Source:** National Science Foundation

chemical engineering the decline in funding is substantial

1988	1987			1986			1985		
Metallurgy & materials	All engineering	Chemical engineering	Metallurgy & materials	All engineering	Chemical engineering	Metallurgy & materials	All engineering	Chemical engineering	Metallurgy & materials
$294.4	**$1629.7**	**$ 46.9**	**$203.6**	**$1505.6**	**$ 50.3**	**$253.7**	**$1502.0**	**$ 53.3**	**$260.9**
43.2	460.3	1.8	34.5	444.7	1.9	33.4	423.9	1.7	28.6
23.8	442.4	23.8	32.1	373.6	24.0	26.8	344.3	26.7	42.2
52.5	401.5	21.3	57.2	397.8	24.4	117.4	421.2	24.8	121.1
174.8	325.6	0	79.8	289.5	0	76.2	312.6	0.1	69.0
18.8	**1170.5**	**1.5**	**19.9**	**1066.9**	**1.0**	**16.2**	**931.6**	**0.6**	**15.8**
78.4	**442.2**	**88.9**	**77.1**	**494.2**	**121.6**	**82.8**	**511.3**	**136.6**	**68.4**
25.6	**191.7**	**37.3**	**22.9**	**199.1**	**33.4**	**43.5**	**193.3**	**32.6**	**42.7**
3.6	**48.1**	**1.0**	**0.7**	**52.8**	**1.9**	**1.8**	**49.4**	**0.6**	**1.5**
24.8	**87.8**	**5.0**	**28.5**	**93.2**	**4.7**	**38.5**	**100.2**	**4.8**	**39.8**
0.3	**55.4**	**25.6**	**0.5**	**48.6**	**23.9**	**0.5**	**44.8**	**18.0**	**2.6**
10.6	**41.3**	**2.4**	**8.6**	**41.7**	**2.6**	**7.6**	**39.8**	**1.7**	**6.9**
0	**33.9**	**6.9**	**0**	**31.1**	**6.0**	**0**	**28.7**	**5.6**	**0**
0.2	**205.8**	**0.3**	**0.2**	**205.9**	**0.4**	**0.5**	**227.4**	**0.3**	**0.5**
$456.7	**$3906.2**	**$215.8**	**$362.0**	**$3738.9**	**$245.8**	**$445.0**	**$3628.5**	**$254.1**	**$439.1**
26%	**4%**	**−12%**	**−19%**	**3%**	**−3%**	**1%**	**0%**	**76%**	**29%**

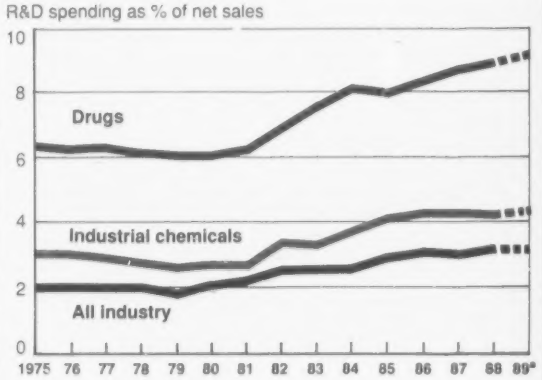
Chemical Industry R&D Rose 11% in 1989

In real terms, R&D spending for all chemicals nearly doubled in past decade



Note: Constant-dollar values calculated by C&EN based on NSF data.
Source: National Science Foundation

Drug firms outpace others in share of revenues spent for R&D



a C&EN estimates. **Source:** National Science Foundation

TOTAL FUNDS FOR INDUSTRIAL R&D: Outlays edge above the $100 billion mark

$ Millions	1989a	1988	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978	Annual change 1987–88	Annual change 1978–88
Chemicals and allied products	$ 11,900	$10,774	$ 9,878	$ 8,843	$ 8,540	$ 7,927	$ 7,185	$ 6,604	$ 5,625	$ 4,636	$ 4,038	$ 3,580	9%	11%
Industrial chemicals	4,250	3,959	3,901	3,552	3,498	3,240	3,214	3,206	2,802	2,197	1,962	1,798	1	8
Drugs	5,400	4,737	4,108a	3,658	3,490a	3,316a	2,901a	2,481a	2,073a	1,777	1,517	1,308	16	14
Other chemicals	2,250	2,078	1,869a	1,633	1,552a	1,371a	1,070a	917a	750a	662	559	474	12	16
Other industries	91,100	88,648	84,239	79,336	75,699	66,873	$58,083	52,046	46,185	39,869	34,188	29,724	5	11
TOTAL	$103,000	$99,422	$94,117	$88,179	$84,239	$74,800	$65,268	$58,650	$51,810	$44,505	$38,226	$33,304	5%	11%

a C&EN estimates. **Source:** National Science Foundation

COMPANY FUNDS FOR INDUSTRIAL R&D: Growth for chemicals outstrips that for other industries

$ Millions	1988	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978	Annual change 1987–88	Annual change 1978–88
Chemicals and allied products	$10,580	$ 9,685	$ 8,664	$ 8,310	$ 7,736	$ 6,792	$ 6,197	$ 5,205	$ 4,264	$ 3,692	$ 3,250	9%	13%
Industrial chemicals	3,767	3,714	3,374	3,281	3,057	2,828	2,810	2,393	1,856	1,617	1,473	1	10
Drugs	4,735	4,139	3,657	3,481	3,310	2,896	2,473	2,064	1,756	1,516a	1,304a	14	14
Other chemicals	2,078	1,832	1,633	1,548	1,369	1,068	914	747	653	559a	473a	13	16
Other industries	55,883	53,121	51,268	48,733	43,668	37,796	33,908	30,223	26,212	22,016	18,865	5	11
TOTAL	$66,463	$62,806	$59,932	$57,043	$51,404	$44,588	$40,105	$35,428	$30,476	$25,708	$22,115	6%	12%

a C&EN estimates. **Source:** National Science Foundation

FEDERAL FUNDS FOR INDUSTRIAL R&D: **Chemical industry gets less than 1% of total**

$ Millions	1988	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978	Annual change 1987–88	Annual change 1978–88
Chemicals and allied products	$ 195	$ 192	$ 179	$ 230	$ 191[a]	$ 393	$ 407	$ 421	$ 372	$ 346	$ 330	2%	−5%[a]
Industrial chemicals	192	187	178	217	183[a]	386	396	409	341	345	325	3	−5[a]
Drugs and other chemicals	3	5	1	13	8	7	11	12	31	1	5	—	—
Other industries	32,764	31,119	28,068	26,966	23,205	20,287	18,138	15,961	13,657	12,172	10,859	5	12
TOTAL	$32,959	$31,311	$28,247	$27,196	$23,396	$20,680	$18,545	$16,382	$14,029	$12,518	$11,189	5%	11%

a The decline in 1984 from 1983 results from the administration of federally funded Oak Ridge National Laboratory being changed from a chemical company to a company in the aircraft and missile industry. **Source:** National Science Foundation

COST PER INDUSTRIAL R&D SCIENTIST OR ENGINEER: **Chemicals top all industry for a change**

$ Thousands	1988	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978
Chemicals and allied products	$140.6	$132.8	$118.9	$116.3	$112.5	$104.8	$102.5	$ 96.6	$ 87.4	$79.6	$72.8
Industrial chemicals	a	a	144.1	144.6	132.0	123.1	122.1	118.0	103.4	92.8	84.2
Drugs	141.5	a	120.1	a	a	103.1	a	a	79.2	71.4	64.8
Other chemicals	a	a	84.6	a	a	a	a	a	66.5	66.5	61.6
All industry	$138.7	$133.9	$128.9	$130.2	$124.0	$116.0	$111.6	$103.9	$ 94.9	$87.4	$80.4

a Not separately available but included in chemicals and allied products. **Source:** National Science Foundation

R&D BY U.S. COMPANIES ABROAD: **Spending by chemical firms is escalating rapidly**

$ Millions	1988	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978	Annual change 1987–88	Annual change 1978–88
Chemicals and allied products	$1540	$1243	$1071	$ 843	$ 786	$ 729	$ 682	$ 715	$ 603	$ 500	$ 395	24%	15%
Industrial and other chemicals	774	625	579	444	385	368	319	287	246	199	151	24	18
Drugs	766	618	492	399	401	361	363	428	357	301	244	23	12
Other industries	4708	3983	3553	2807	2847	2540	2412	2679	2562	2254	1814	18	10
TOTAL	$6248	$5226	$4624	$3650	$3633	$3269	$3094	$3393	$3165	$2754	$2209	20%	11%

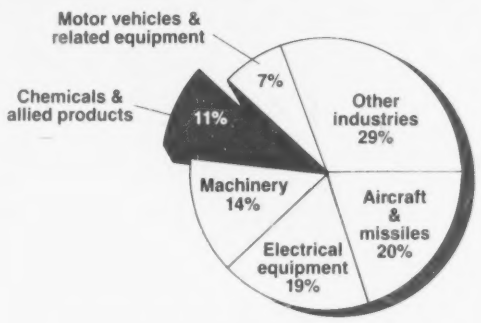
Source: National Science Foundation

CHEMICAL R&D SPENDING: **Growth in company budgets slowed last year**

$ Millions	1989	1988	1987	1986	1985	1984	1983	1982	1981	1980	1979	1989 R&D spending as % of sales
Du Pont	$1387	$1319	$1223	$1156	$1144	$1097	$ 966	$ 879	$ 718	$ 591	$ 509	3.9%
Dow Chemical	873	772	670	605	547	507	492	460	404	314	269	5.0
Monsanto	598	648	615	596	470	370	290	264	233	208	161	6.9
American Cyanamid	406	365	314	278	251	232	208	185	166	148	130	8.4
Union Carbide[a]	181	159	159	148	275	265	245	240	207	166	161	2.1
Rohm & Haas	175	156	142	133	124	109	100	92	77	67	54	6.6
W. R. Grace	125	119	107	94	92	81	73	64	57	45	42	2.0
Hercules	79	74	74	71	76	72	74	74	65	57	50	2.6
Air Products	71	72	57	61	51	44	40	37	32	30	24	2.7
Lubrizol	70	65	62	51	44	33	37	36	33	28	23	5.7
Olin	66	58	62	56	53	52	49	45	38	31	26	2.6
Ethyl	61[b]	59[b]	50	47	47	40	39	39	37	34	29	4.0
International Flavors	52	50	45	39	34	32	32	31	30	29	27	6.0
Nalco Chemical	41	37	35	33	32	32	30	33	30	28	21	3.8
TOTAL	$4185	$3953	$3615	$3368	$3240	$2966	$2675	$2479	$2127	$1776	$1526	4.3%
ANNUAL CHANGE	6%	9%	7%	4%	9%	11%	8%	17%	20%	16%	12%	

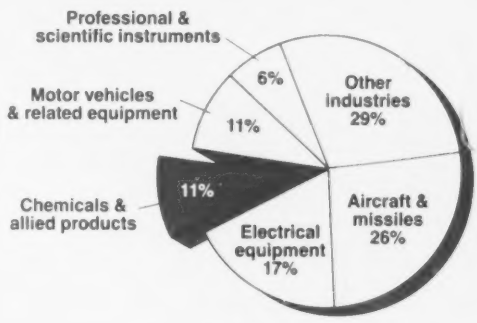
Note: Prior years not restated to reflect company revisions. a Union Carbide divested a substantial part of its business in 1986; on a pro forma basis, R&D spending was $181 million in 1985 and $178 million in 1984. b Adjusted to reflect spin-off of Tredegar Industries. **Source:** Company data

Chemical firms provide work for 11% of R&D scientists and engineers in industry...



1989 total industrial R&D scientists and engineers[a] = 724,900

...and also account for 11% of total industrial R&D outlays in the U.S.



1989 total industrial R&D expenditures = $99.4 million

a Full-time equivalent as of January 1989. **Source:** National Science Foundation

R&D SCIENTISTS AND ENGINEERS IN INDUSTRY: Total rises only slightly

Thousands	1989	1988	1987	1986	1985	1984	1983	1982	1981	1980	1979	Annual change 1988–89	Annual change 1979–89
Chemicals and allied products	**77.4**	**75.8**	**73.0**	**75.8**	**71.1**	**69.8**	**67.3**	**61.6**	**54.7**	**51.4**	**50.0**	**2%**	**4%**
Industrial chemicals	22.0[a]	22.5[a]	24.4	24.9	23.5	25.6	26.6	25.9	21.6	20.9	21.4	1	0
Drugs	33.9	33.0	29.1	31.8	30.8	30.8[a]	28.2	25.6	23.3	21.6	20.8	3	5
Other chemicals	20.7[a]	20.3	19.5	19.1	16.7	13.4	12.1	10.1	9.8	8.9	7.8	2	9
Other industries	**647.5**	**632.8**	**624.3**	**595.2**	**551.4**	**514.3**	**473.6**	**448.2**	**433.1**	**399.2**	**373.9**	**2**	**6**
TOTAL	**724.9**	**708.6**	**697.3**	**671.0**	**622.5**	**584.1**	**540.9**	**509.8**	**487.8**	**450.6**	**423.9**	**2%**	**6%**

Note: Data as of January of each year for full-time equivalent personnel. a C&EN estimates. **Source:** National Science Foundation

CHEMISTS IN INDUSTRY: More than half work in some sector of the chemical industry

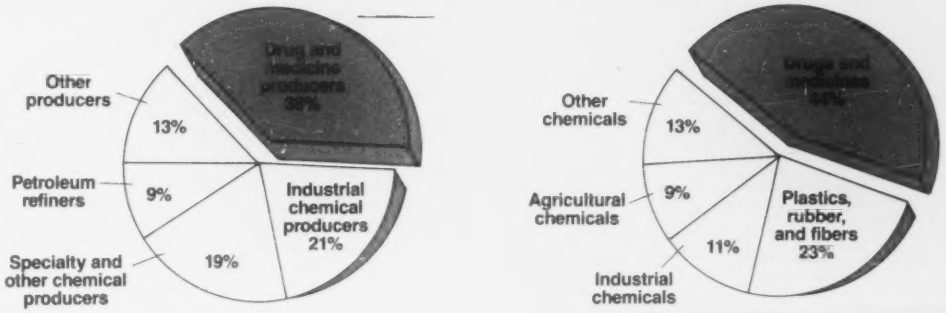
Industry	% of industrial chemists				Mean salary ($ thousands)[a]		
	All chemists	B.S.	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Pharmaceuticals[b]	19%	17%	21%	19%	$44.0	$52.1	$69.8
Specialty chemicals	15	14	13	17	44.8	52.9	64.8
Basic chemicals	6	4	5	8	45.9	53.5	65.6
Plastics	5	4	5	6	45.6	53.8	66.3
Coatings	4	6	5	3	44.5	51.6	61.2
Petroleum and natural gas	4	4	4	5	48.4	56.5	71.3
Agricultural chemicals	4	3	4	5	41.7	48.7	63.6
Electronics	4	3	3	4	45.6	51.8	67.2
Food	3	4	4	3	43.4	51.8	65.8
Aerospace	3	2	3	3	46.8	54.4	63.3
Biochemical products	2	1	2	2	42.8	51.2	66.8
Metals and minerals	2	3	2	1	40.7	50.6	62.2
Rubber	2	3	2	1	44.8	53.3	60.5
Soaps and detergents	1	2	1	1	45.9	53.3	63.5
Paper	1	1	1	1	42.1	56.8	60.4
Other manufacturing	13	14	13	12	42.2	53.2	65.1
Nonmanufacturing	15	15	13	9	43.4	52.7	63.4

a As of March 1, 1990; to facilitate comparison, mean salaries are adjusted for differences in average length of experience for each group. b Includes personal care products. **Source:** ACS survey

Drug companies perform the largest share of chemical R&D...

...and research on drugs takes up the biggest part of such R&D funds

1987 chemical R&D spending[a] = $4.4 billion



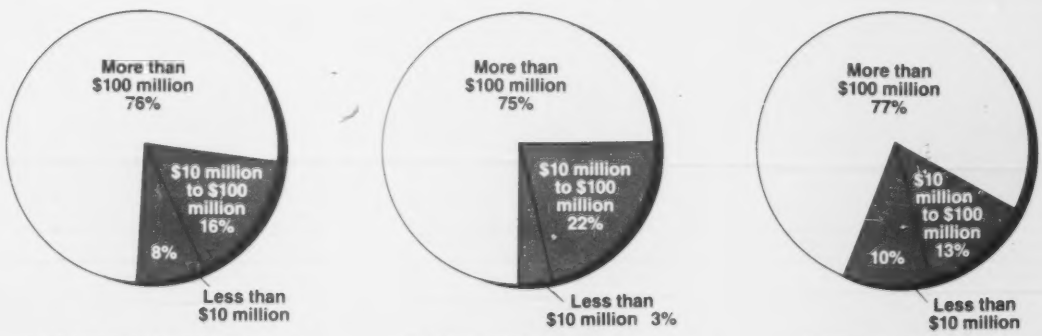
a Excludes basic research. **Source:** National Science Foundation

R&D SCIENTISTS AND ENGINEERS PER 1000 EMPLOYEES: Almost 100 for drug companies

	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977
Chemicals and allied products	**68**	**70**	**57**	**57**	**54**	**51**	**44**	**42**	**42**	**43**	**42**
Industrial chemicals	53	56	39	41	45	44	37	36	36	38	38
Drugs	97	98	81	89	82	74	66	60	62	65	62
Other chemicals	59	63	62	51	39	37	33	30	27	27	29
All industry	**45**	**45**	**43**	**40**	**34**	**33**	**29**	**27**	**27**	**27**	**27**

Source: National Science Foundation

Chemical firms with largest research budgets do at least three fourths of all chemical R&D


More than $100 million 76%
$10 million to $100 million 16%
8%
Less than $10 million
More than $100 million 75%
$10 million to $100 million 22%
Less than $10 million 3%
More than $100 million 77%
$10 million to $100 million 13%
10%
Less than $10 million

1988 chemicals and allied products R&D funds = $10.8 billion

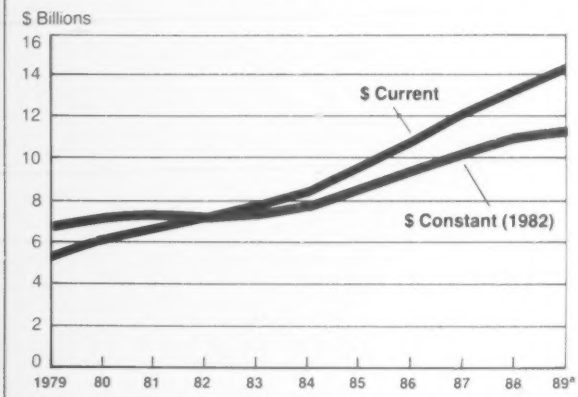
1988 industrial chemicals R&D funds = $4.0 billion

1988 industry R&D funds = $99.4 billion

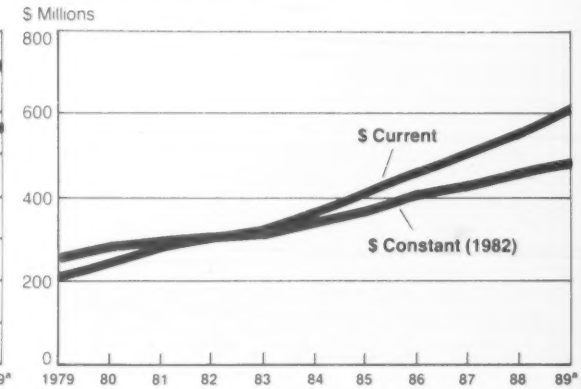
Note: Ranges indicate size of companies' 1988 R&D program. **Source:** National Science Foundation

Universities' R&D Outlays Top $13 Billion

In real terms, R&D funding at universities rose about two thirds in the past decade . . .



. . . and is up more than 80% for chemical research alone



Note: Data for institutional fiscal years. a C&EN estimates. Source: National Science Foundation

CHARACTER OF UNIVERSITY R&D SPENDING: Funds for applied work rose sharply in 1988

$ Millions	1988	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978a	Annual change 1987–88	Annual change 1978–88
Basic research	$ 8,870	$ 8,343	$ 7,476	$6539	$5709	$5288	$4864	$4578	$4024	$3612	$3176	6%	11%
Applied research and development	4,552	3,737	3,428	3124	2885	2576	2442	2267	2037	1749	1449	22	12
TOTAL	$13,422	$12,080	$10,904	$9663	$8594	$7864	$7306	$6829	$6062	$5361	$4625	11%	11%
ANNUAL CHANGE	11%	11%	13%	12%	9%	8%	7%	13%	13%	16%	14%		

Note: Data for institutional fiscal years. Data since 1980 were revised in 1988. a NSF estimates, based on data from Ph.D.-granting institutions only. Source: National Science Foundation

SOURCE OF UNIVERSITY R&D FUNDS: Industry's support up 18% annually in past decade

$ Millions	1988	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978a	Annual change 1987–88	Annual change 1978–88
Federal government	$ 8,165	$ 7,328	$ 6,702	$6056	$5416	$4980	$4759	$4561	$4096	$3595	$3059	11%	10%
Institutional funds	2,314	2,114	1,858	1609	1406	1297	1106	995	835	728	623	9	14
State and local governments	1,123	1,020	913	748	686	623	614	546	491	470	414	10	11
Industry	892	807	717	561	474	389	339	294	238	194	170	11	18
Other sources	928	810	713	690	612	578	489	434	401	374	359	15	10
TOTAL	$13,422	$12,080	$10,904	$9663	$8594	$7864	$7306	$6829	$6062	$5361	$4625	11%	11%

Note: Data for institutional fiscal years. Data since 1980 were revised in 1988. a NSF estimates, based on data from Ph.D.-granting institutions only. Source: National Science Foundation

FIELDS OF UNIVERSITY R&D SPENDING: 5% of total goes to chemistry and chemical engineering

$ Millions	1988	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978[a]	Annual change 1987–88	Annual change 1978–88
All sciences	**$11,338**	**$10,195**	**$ 9,267**	**$8250**	**$7375**	**$6741**	**$6273**	**$5861**	**$5196**	**$4593**	**$4024**	**11%**	**11%**
Life	7,236	6,476	5,885	5272	4706	4299	4008	3689	3218	2833	2538	12	11
Physical	1,532	1,382	1,281	1144	995	899	823	765	678	602	469	11	13
Physics	726	662	628	549	471	417	366	357	322	292	235	10	12
Chemistry	566	510	469	422	372	335	308	285	245	206	183	11	12
Environmental	891	828	773	702	645	617	558	550	509	453	379	8	9
Psychology and social	764	688	629	534	504	479	483	494	453	396	367	11	8
Computer	410	372	321	281	224	175	149	132	114	98	67	10	20
Mathematical	199	178	152	128	123	106	96	87	79	79	59	12	13
Others	308	271	226	185	179	165	156	145	146	134	117	14	10
Engineering	**2,084**	**1,885**	**1,636**	**1414**	**1219**	**1124**	**1034**	**968**	**866**	**768**	**601**	**11**	**13**
Chemical	154	140	125	109	95	91	83	76	68	na	na	10	—
TOTAL	**$13,422**	**$12,080**	**$10,904**	**$9663**	**$8594**	**$7864**	**$7306**	**$6829**	**$6062**	**$5361**	**$4625**	**11%**	**11%**
ANNUAL CHANGE	**11%**	**11%**	**13%**	**12%**	**9%**	**8%**	**7%**	**13%**	**13%**	**16%**	**14%**		

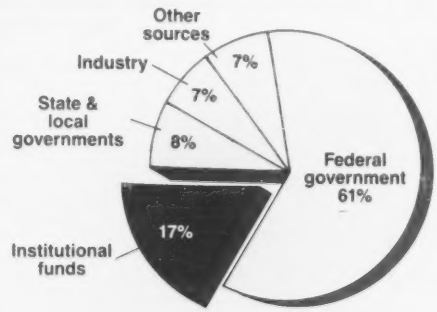
Note: Data for institutional fiscal years. Data since 1980 were revised in 1988. a NSF estimates, based on data from Ph.D-granting institutions only. na = not available. **Source:** National Science Foundation

FEDERALLY FINANCED R&D SPENDING AT UNIVERSITIES: Steady growth continues

$ Millions	1988	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978[a]	Annual change 1987–88	Annual change 1978–88
All sciences	**$6940**	**$6220**	**$5726**	**$5190**	**$4637**	**$4240**	**$4061**	**$3898**	**$3500**	**$3069**	**$2651**	**12%**	**10%**
Life	4311	3827	3491	3186	2828	2587	2503	2365	2094	1819	1626	13	10
Physical	1145	1042	979	888	779	700	650	619	555	491	392	10	11
Physics	573	528	509	452	389	342	306	309	280	253	199	9	11
Chemistry	403	365	338	313	279	248	230	217	190	157	138	10	11
Environmental	584	542	517	473	446	426	391	391	372	329	275	8	8
Psychology and social	328	295	286	259	241	236	250	280	263	227	204	11	5
Computer	289	257	232	195	163	128	107	93	77	69	41	12	22
Mathematical	149	132	114	97	92	76	72	68	61	60	44	13	13
Others	134	126	107	92	87	87	88	82	78	73	68	6	7
Engineering	**1225**	**1108**	**975**	**866**	**780**	**739**	**697**	**662**	**596**	**526**	**408**	**11**	**12**
Chemical	79	69	66	58	54	52	50	48	46	na	na	14	—
TOTAL	**$8165**	**$7328**	**$6702**	**$6056**	**$5417**	**$4980**	**$4759**	**$4561**	**$4096**	**$3595**	**$3059**	**11%**	**10%**
ANNUAL CHANGE	**11%**	**9%**	**11%**	**12%**	**9%**	**5%**	**4%**	**11%**	**14%**	**18%**	**12%**		

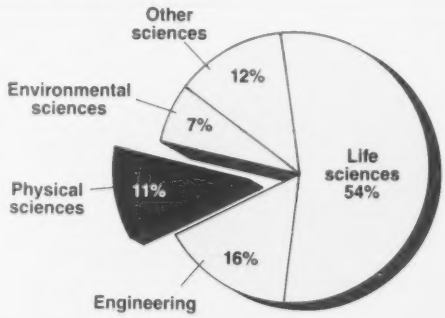
Note: Data for institutional fiscal years. Data since 1980 were revised in 1988. a NSF estimates, based on data from Ph.D.-granting institutions only. na = not available. **Source:** National Science Foundation

Academic institutions fund less than a fifth of all academic R&D . . .



Fiscal 1988 academic R&D expenditures = $13.4 billion

. . . only about one tenth of which is in physical sciences



Fiscal 1988 academic R&D expenditures = $13.4 billion

Source: National Science Foundation

TOP 10 UNIVERSITY R&D CENTERS: They account for 96% of federal support at all centers

$ Millions, fiscal 1988	Physical sciences	Engineering	Math & computer sciences	Environmental sciences	Life sciences	Psychology & social sciences	Other sciences	Total
1 Jet Propulsion Lab	$ 124.7	$ 442.0	$391.0	$101.5	$ 0	$ 0	$0	$1059.3
2 Lawrence Livermore Lab	285.0	457.0	138.6	31.6	26.9	0	0	939.1
3 Los Alamos National Lab	426.3	298.8	77.3	21.0	29.5	26.1	3.4	882.4
4 Lincoln Lab	72.9	273.2	39.7	0	0	0.4	0	386.2
5 Argonne National Lab	93.4	134.9	5.4	57.1	12.5	0	0	303.3
6 Brookhaven National Lab	169.1	36.9	0.6	7.4	19.3	0.6	0.2	234.2
7 Lawrence Berkeley Lab	138.6	0.1	2.3	11.2	25.0	0	6.0	183.2
8 Fermi National Accelerator Lab	168.7	0	0	0	4.5	0	0	173.2
9 Plasma Physics Lab	103.5	0	0	0	0	0	0	103.5
10 Stanford Linear Accelerator Center	98.0	0	0	0	0	0	0	98.0
All others	76.1	4.4	20.6	59.6	5.7	1.7	0	168.1
TOTAL, ALL FEDERALLY FUNDED R&D CENTERS	$1756.4	$1647.4	$675.5	$289.4	$123.5	$28.8	$9.6	$4530.6

Note: Data for university-administered, federally funded R&D centers. A number of institutions have developed or are in the process of developing new computer systems and methodologies that enable them to report more accurately the total cost of science and engineering research. Fiscal 1988 comparisons with data reported in earlier years may be inappropriate in some areas. **Source:** National Science Foundation

CAPITAL SPENDING AT UNIVERSITIES: Funds for physical sciences jump nearly a third

$ Millions	1988 Total spending	1988 % federal funds	1987	1986	1985	1984	1983	Annual change 1987–88	Annual change 1983–88
All sciences	$1600.4	10%	$1367.5	$1184.3	$1045.8	$1028.8	$ 956.4	17%	11%
Life sciences	1056.4	7	915.1	772.0	697.7	717.0	668.5	15	10
Physical sciences	209.2	18	159.7	144.0	115.7	110.7	98.1	31	16
Mathematical and computer sciences	96.3	0	83.4	90.6	77.2	48.9	54.2	15	12
Psychology and social sciences	92.0	0	65.0	67.7	73.6	78.3	57.7	42	10
Environmental sciences	58.6	0	54.2	49.0	54.6	36.4	42.2	8	7
Other sciences	87.9	0	90.2	60.9	27.0	37.7	35.7	−3	20
Engineering	366.5	0	380.3	314.8	184.0	147.1	137.2	−4	22
TOTAL	$1966.9	11%	$1747.9	$1499.1	$1229.8	$1175.9	$1093.6	13%	12%
ANNUAL CHANGE	13%	—	17%	22%	5%	8%	13%		

Note: Data for institutional fiscal years. Includes expenditures for facilities and equipment for research, development, and instruction. **Source:** National Science Foundation

UNIVERSITY SPENDING FOR RESEARCH EQUIPMENT: Hefty increase for chemistry in 1988

$ Millions	1988 Total	1988 Federal funds	1987 Total	1987 Federal funds	1981 Total	1981 Federal funds	Annual change 1987–88 Total	Annual change 1987–88 Federal funds	Annual change 1981–88 Total	Annual change 1981–88 Federal funds
All sciences	$668.9	$414.4	$604.4	$378.6	$336.9	$213.7	11%	10%	10%	10%
Life sciences	384.2	213.2	334.7	187.1	194.9	117.4	15	14	10	9
Physical sciences	180.3	141.6	164.6	129.7	77.1	59.3	10	9	13	13
Physics	84.4	67.2	79.9	66.0	32.8	26.7	6	2	14	14
Chemistry	74.4	57.6	65.6	48.6	35.3	25.6	13	19	11	12
Environmental sciences	55.7	36.8	56.0	36.4	31.1	18.9	−1	1	9	10
Mathematical and computer sciences	54.1	42.2	52.5	41.5	15.1	9.0	3	2	20	25
Other sciences	48.8	22.9	49.0	25.5	20.9	11.7	−1	−10	13	10
Engineering	195.7	118.0	178.7	105.4	72.7	45.1	10	12	15	15
Chemical	14.9	8.0	14.3	7.5	7.0	4.4	5	6	11	9
TOTAL	$918.7	$574.6	$835.6	$525.6	$411.7	$261.3	10%	9%	12%	12%

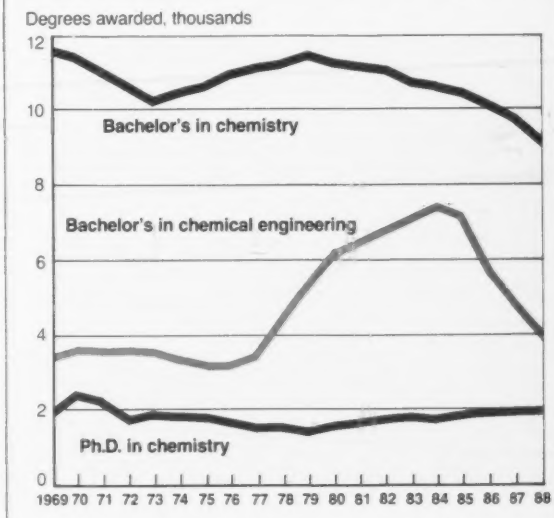
Note: Data for institutional fiscal years. **Source:** National Science Foundation

CHEMICAL DEGREES: Only increases during past decade are at Ph.D. level

Academic year	Degrees awarded in chemistry			Degrees awarded in chemical engineering		
	Bachelor's	Master's	Ph.D.	Bachelor's	Master's	Ph.D.
1969	11,807	2070	1941	3557	1136	409
1970	11,617	2146	2208	3720	1045	438
1971	11,183	2284	2160	3615	1100	406
1972	10,721	2259	1971	3663	1154	394
1973	10,226	2230	1882	3636	1051	397
1974	10,525	2138	1828	3454	1045	400
1975	10,649	2006	1824	3142	990	346
1976	11,107	1796	1623	3203	1031	308
1977	11,322	1775	1571	3581	1086	291
1978	11,474	1892	1525	4615	1237	259
1979	11,643	1765	1518	5655	1149	304
1980	11,446	1733	1551	6383	1271	284
1981	11,347	1654	1622	6527	1267	300
1982	11,062	1751	1722	6740	1285	311
1983	10,746	1604	1746	7145	1304	319
1984	10,704	1667	1744	7475	1514	330
1985	10,482	1719	1789	7146	1544	418
1986	10,116	1754	1908	5877	1361	446
1987	9,661	1738	1976	4983	1184	497
1988	9,025	1694	1990	3926	1103	579

Source: National Center for Education Statistics

Bachelor's degrees continue to drop



Note: Academic years. **Source:** National Center for Education Statistics

TOP 10 UNIVERSITIES IN R&D SPENDING: Four universities vie for second place

$ Millions, fiscal 1987	Physical sciences	Chemistry[a]	Engineering	Environmental sciences	Life sciences	Math & computer sciences	Other sciences	Total
1 Johns Hopkins U	$ 96.7	$ 5.2	$ 162.4	$ 33.0	$ 156.6	$ 90.3	$ 18.0	$ 557.0
2 Stanford U	56.6	10.5	75.8	4.5	117.8	16.5	6.3	277.5
3 Cornell U	42.5	10.5	39.8	7.0	149.5	19.5	13.4	271.7
4 U of Wisconsin, Madison	25.6	7.3	32.3	20.6	156.0	6.8	30.1	271.4
5 Massachusetts Institute of Technology	84.6	13.3	107.3	11.7	34.8	12.5	19.7	270.6
6 U of Minnesota	12.6	5.2	25.5	6.3	186.3	5.7	15.7	252.0
7 U of Michigan	15.7	3.9	42.8	14.6	132.0	3.0	42.0	250.2
8 Texas A&M U	15.2	8.8	37.5	56.2	101.2	3.2	17.7	231.2
9 U of California, Los Angeles	20.8	9.5	21.5	11.3	125.4	6.8	23.6	209.3
10 U of California, San Diego	25.1	6.8	4.5	70.2	89.8	7.1	3.8	200.5
TOTAL, FIRST 10 INSTITUTIONS	$ 395.5	$ 81.0	$ 549.4	$235.3	$1249.2	$171.5	$ 190.4	$ 2,791.3
TOTAL, ALL INSTITUTIONS	$1531.6	$565.6	$2083.7	$890.9	$7236.1	$608.4	$1071.4	$13,422.1

Note: Data for institutional fiscal years. A number of institutions have developed or are in the process of developing new computer systems and methodologies that enable them to report more accurately the total cost of science and engineering research. Fiscal 1988 comparisons with data reported in earlier years may be inappropriate in some areas. a Included in physical sciences. **Source:** National Science Foundation

SCHOOLS SPENDING MOST ON CHEMICAL R&D: Ten spent almost one fifth of total in 1988

Rank 1988	Rank 1987		1988 Total spending ($ thousands)	1988 % federal funds	1987	1986	1985	1984	1983	Annual change 1987–88	Annual change 1983–88
					($ thousands)						
1	1	U of California, Berkeley	$ 14,285	91%	$ 12,490	$ 9,114	$ 10,804	$ 7,850	$ 7,945	14%	12%
2	2	Massachusetts Inst. of Technology	13,287	90	11,471	13,593	13,221	11,741	8,914	16	8
3	3	U of Texas, Austin	10,943	59	11,420	8,531	7,908	6,639	5,938	−4	13
4	8	Stanford University	10,547	89	8,916	8,340	8,354	6,809	6,375	18	11
5	10	Cornell U	10,472	79	8,397	7,376	7,962	6,710	5,717[a]	25	13
6	4	California Inst. of Technology	9,931	88	10,870	9,176	7,605	6,446	6,994	−9	7
7	9	Harvard U	9,886	94	8,895	7,202	6,557[a]	6,307[a]	6,898[a]	11	7
8	5	U of California, Los Angeles	9,519	93	10,099	7,954	7,243	7,219	5,496	−6	12
9	13	Texas A&M U	8,785	56	7,462	7,230[a]	6,768[a]	5,606[a]	4,963	17	12
10	7	U of Illinois, Urbana	8,647	72	9,035	8,604	7,079	6,284	5,886	−4	8
		Total, first 10 institutions	$106,302	82%	$ 99,055	$ 87,120	$ 83,501	$ 71,611	$ 65,126	7%	10%
11	15	Purdue U	8,615	83	7,092	6,315	6,018	5,443	4,542	21	14
12	6	U of Maryland, College Park	8,545	44	9,258	7,904	7,289	6,324	6,333[a]	−7	6
13	20	Princeton U	8,087	72	6,477	5,702	3,963	3,670	3,509	25	18
14	12	U of Chicago	8,046	90	7,514	7,553[a]	6,921[a]	5,735	4,798	7	11
15	14	Case Western Reserve U	7,996	68	7,164	2,922[a]	2,802	2,759	2,232	12	29
16	21	Indiana U	7,991	80	6,181	6,110	5,820	5,642	5,551	29	8
17	23	Pennsylvania State U	7,739	77	6,072	6,438	6,509	5,124	4,729	27	10
18	24	Ohio State U	7,568	72	5,755	6,546	5,422	4,104	3,739	32	15
19	18	U of Pennsylvania	7,292	87	6,741	6,064	5,025	4,375	4,982	8	8
20	16	U of Wisconsin, Madison	7,282	68	6,984	7,892	7,350	6,076	5,310	4	7
		Total, first 20 institutions	$185,463	79%	$168,293	$150,566	$140,620	$120,863	$110,851	10%	11%
21	27	U of Notre Dame	7,004	94	5,550	5,402	5,549	4,760	4,022	26	12
22	17	Rockefeller U	6,975	44	6,823	7,335	4,826[a]	1,178	919	2	50
23	19	Columbia U, main division	6,931	94	6,715	5,555	5,188	4,662	4,281	3	10
24	28	Yale U	6,869	86	5,538	6,169[a]	5,600[a]	4,134	3,341	28	16
25	30	U of California, San Diego	6,780	91	5,179	6,535	4,642	4,355	3,910	31	12
26	22	Northwestern U	6,644	75	6,095	4,826	5,062	4,557	3,413	9	14
27	33	Georgia Inst. of Technology	5,989	60	4,889	5,260	3,684	3,846	3,401	23	12
28	42	Rutgers U	5,926	58	3,913	3,507	2,368	2,301	1,830	51	26
29	31	U of Colorado	5,637	82	5,118	5,830	6,360	4,134	3,302	10	11
30	32	U of Pittsburgh	5,598	86	5,105	4,974	4,580	3,965	3,267	10	11
		Total, first 30 institutions	$249,816	78%	$223,218	$205,959	$188,479	$158,755	$142,537	12%	12%
31	36	U of Oregon, main campus	5,550	81	4,462	5,087	4,640	4,255	3,351	24	11
32	11	U of Massachusetts, Amherst	5,280	62	7,589	6,967	6,420	6,347	5,162	−30	0
33	29	U of Minnesota	5,239	79	5,426	5,110	4,167	4,067	4,047	−3	5
34	26	Johns Hopkins U	5,211	93	5,593	5,506	4,652[a]	4,030	4,592[a]	−7	3
35	25	U of Florida	5,030	63	5,690	4,750	4,380	4,024	2,347	−12	16
36	48	State U of New York, Stony Brook	5,010	69	3,669	3,333	3,481	3,084	2,607	37	14
37	46	Colorado State U	4,950	86	3,713	3,867	2,775	2,688	2,478	33	15
38	38	Virginia Polytechnic Inst. & State U	4,735	51	4,190	3,786	3,417	2,686	2,206	13	17
39	34	U of Utah	4,600	79	4,846	5,354	4,840	3,830	3,638	−5	5
40	60	Wayne State U	4,582	47	3,278	3,405	2,903	3,071	2,645	40	12
		Total, first 40 institutions	$300,003	77%	$271,674	$253,124	$230,154	$196,837	$175,610	10%	11%
41	53	U of California, Irvine	4,534	97	3,541	3,486	3,142	2,177	1,777	28	21
42	37	Lehigh U	4,510	43	4,410	4,237	3,456	3,361	3,664	2	4
43	54	U of North Carolina, Chapel Hill	4,476	94	3,471	3,352	3,386	2,945	2,397	29	13
44	52	U of Rochester	4,437	89	3,545	3,584	3,196	3,858	3,167	25	7
45	49	U of Washington	4,338	67	3,655	2,971	2,964	2,340	2,162	19	15
46	44	Florida State U	4,308	33	3,841	4,047	3,276	3,137	2,500	12	11
47	57	U of Connecticut	4,279	26	3,396	3,380	3,429	4,135	2,720	26	9
48	39	U of Virginia	4,153	82	4,169	3,436	3,046	2,516	2,069	0	15
49	35	U of South Carolina	4,078	70	4,622	4,432	3,850	3,423	2,721	−12	8
50	45	U of Cincinnati	4,008	52	3,816	1,684	1,593	1,633	1,217	5	27
		Total, first 50 institutions	$343,124	76%	$310,140	$287,733	$261,492	$226,362	$200,034	11%	11%
		NATIONAL TOTAL	$565,637	71%	$509,512	$468,778	$421,506	$369,945	$334,663	11%	11%

Note: Data for institutional fiscal years. A number of institutions have developed or are in the process of developing new computer systems and methodologies that enable them to report more accurately the total cost of science and engineering research. Fiscal year 1988 comparisons with data reported in earlier years may be inappropriate in some areas. Data since 1985 were revised in 1988. a Estimated. **Source:** National Science Foundation

SCHOOLS WITH MOST FEDERAL SUPPORT FOR CHEMICAL R&D: Two get over $10 million each

Rank 1988	Rank 1987		1988	1987	1986	1985	1984	1983	Annual change 1987–88	Annual change 1983–88
			($ thousands)							
1	1	U of California, Berkeley	$ 12,998	$ 11,160	$ 8,258	$ 9,892	$ 7,263	$ 7,467	16%	12%
2	2	Massachusetts Inst. of Technology	11,987	10,656	12,909	12,424	11,055	8,374	12	7
3	6	Stanford U	9,423	7,918	7,524	7,097	6,120	5,968	19	10
4	5	Harvard U	9,272	8,309	6,748	6,557	6,307	5,224	12	12
5	4	U of California, Los Angeles	8,885	9,414	7,516	6,719	6,389	5,047	−6	12
6	3	California Inst. of Technology	8,769	9,922	7,612	7,001	5,810	6,554	−12	6
7	7	Cornell U	8,269	6,753	5,934	6,293	5,775	4,766	22	12
8	9	U of Chicago	7,235	6,499	6,769[a]	6,265[a]	5,116	3,998	11	13
9	12	Purdue U	7,120	5,978	5,708	5,418	4,452	3,966	19	12
10	14	U of Notre Dame	6,557	5,158	4,998	5,097	4,416	3,867	27	11
		Total, first 10 institutions	$ 90,515	$ 81,767	$ 73,976	$ 72,763	$ 62,703	$ 55,231	11%	10%
11	8	Columbia U, main division	6,519	6,625	5,030	4,490	4,639	4,279	−2	9
12	10	U of Texas, Austin	6,443	6,405	4,922	4,741	3,873	3,527	1	13
13	19	Indiana U	6,354	4,923	4,757	4,885	4,694	4,642	29	6
14	13	U of Pennsylvania	6,337	5,653	5,232	4,398	3,921	4,037	12	9
15	11	U of Illinois, Urbana	6,193	6,306	5,999	5,371	5,005	4,668	−2	6
16	24	U of California, San Diego	6,161	4,599	5,918	4,053	3,780	3,490	34	12
17	20	Pennsylvania State U	5,957	4,915	5,161	5,860	4,564	4,236	21	7
18	21	Yale U	5,927	4,909	5,566[a]	5,095[a]	3,528	3,008	21	15
19	16	Princeton	5,812	5,064	4,575	3,104	2,892	2,642	15	17
20	25	Ohio State U	5,437	4,517	4,931	3,846	2,904	2,870	20	14
		Total, first 20 institutions	$151,655	$135,683	$126,067	$118,606	$102,503	$ 92,630	12%	10%
21	18	Case Western Reserve U	5,433	5,016	2,062	2,065	1,904	1,443	8	30
22	23	Northwestern U	4,955	4,641	3,753	3,963	3,471	3,012	7	10
23	31	Texas A&M U	4,945	4,019	3,128	4,195	2,735	3,327	23	8
24	22	U of Wisconsin, Madison	4,939	4,718	5,348	5,156	4,391	3,693	5	6
25	15	Johns Hopkins U	4,830	5,116	4,903	4,155	3,783	3,604[a]	−6	6
26	30	U of Pittsburgh	4,803	4,028	4,045	3,836	3,343	2,833	19	11
27	26	U of Colorado	4,603	4,402	4,911	5,430	3,358	2,695	5	11
28	32	U of Oregon	4,519	3,579	4,345	3,959	3,524	2,686	26	11
29	35	U of California, Irvine	4,376	3,386	3,394	3,035	2,096	1,725	29	20
30	38	Colorado State U	4,280	3,273	3,403	2,434	2,426	2,055	31	16
		Total, first 30 institutions	$199,338	$177,861	$165,359	$156,834	$133,534	$119,703	12%	11%
31	40	U of North Carolina, Chapel Hill	4,193	3,153	2,929	2,885	2,699	2,381	33	12
32	27	U of Minnesota	4,156	4,395	4,013	3,295	3,346	3,345	−5	4
33	37	U of Rochester	3,936	3,275	3,336	2,861	3,490	2,800	20	7
34	29	U of Maryland, College Park	3,793	4,073	3,557	3,323	2,862	2,834	−7	6
35	28	U of Utah	3,614	4,194	4,791	4,426	3,380	3,085	−14	3
36	45	Georgia Inst. of Technology	3,574	2,565	2,914	2,051	2,227	2,032	39	12
37	42	U of Southern California	3,568	2,903	2,857	2,149	2,495	2,456	23	8
38	43	State U of New York, Stony Brook	3,460	2,930	2,168[a]	2,343	2,069	1,809	18	14
39	46	Rutgers U	3,442	2,525	2,123	2,055	2,129	1,740	36	15
40	36	U of Virginia	3,419	3,281	2,748	2,165	2,099	1,663	4	16
		Total, first 40 institutions	$236,493	$211,155	$196,795	$184,387	$160,330	$143,848	12%	10%
41	44	U of Michigan	3,310	2,615	2,367	2,286	2,356	1,853	27	12
42	17	U of Massachusetts, Amherst	3,296	5,036	4,411	4,091	3,887	3,336	−35	0
43	33	U of California, Santa Barbara	3,196	3,526	3,087	2,709	1,881	1,723	−9	13
44	34	U of Florida	3,168	3,486	2,729	2,302	2,042	1,325	−9	19
45	39	Rockefeller U	3,082	3,247	3,377	2,553	833	584	−5	39
46	60	Carnegie Mellon U	3,001	2,055	1,494	1,569	1,505	1,497	46	15
47	54	U of Washington	2,904	2,287	1,898	2,016	1,919	1,771	27	10
48	48	U of Arizona	2,885	2,499	2,291	1,738	1,843	1,557	15	13
49	63	U of California, Riverside	2,844	1,881	2,108	1,252	1,951	1,343	51	16
50	41	U of South Carolina	2,839	3,113	3,285	2,787	2,533	2,221	−9	5
		Total, first 50 institutions	$267,018	$240,900	$223,842	$207,690	$183,436	$161,058	11%	11%
		NATIONAL TOTAL	$403,018	$365,244	$337,735	$312,831	$278,215	$247,652	10%	10%

Note: Data for institutional fiscal years. A number of institutions have developed or are in the process of developing new computer systems and methodologies that enable them to report more accurately the total cost of science and engineering research. Fiscal year 1988 comparisons with data reported in earlier years may be inappropriate in some areas. Data since 1985 were revised in 1988. a Estimated. **Source:** National Science Foundation

SCHOOLS SPENDING MOST ON CHEMICAL ENGINEERING R&D: Federal funds provide half of total

Rank 1988	Rank 1987		Chemical engineering: Total spending ($ thousands)	Chemical engineering: Federal funds	Chemical engineering: % federal funds	All engineering: Total spending ($ thousands)	All engineering: Federal funds	All engineering: % federal funds
1	1	Massachusetts Inst. of Technology	$ 9,252	$ 6,119	66%	$ 107,281	$ 77,811	73%
2	2	U of Minnesota	6,506	3,647	56	25,498	8,890	35
3	3	U of Texas, Austin	4,315	1,662	39	46,086	21,150	46
4	10	Texas A&M U	4,232	875	21	37,517	11,441	31
5	8	U of Maryland, College Park	3,681	1,238	34	37,807	15,397	41
6	5	Johns Hopkins U	3,654	3,385[a]	92	162,390	159,976	99
7	7	North Carolina State U, Raleigh	3,572	1,036	29	31,219	9,823	31
8	11	Stanford U	3,506	2,954	84	75,828	63,486	84
9	6	U of Wisconsin, Madison	3,351	1,952	58	32,287	21,125	65
10	9	Brigham Young U	3,157	2,704	86	5,308	3,819	72
		Total, first 10 institutions	**$ 45,226**	**$25,572**	**57%**	**$ 561,221**	**$ 392,918**	**70%**
11	18	Case Western Reserve U	2,925	1,662	57	16,062	10,911	68
12	13	U of Delaware	2,673	821	31	9,596	4,025	42
13	16	U of Michigan	2,637	1,866	71	42,808	24,633	58
14	17	Columbia U, main division	2,609	666	26	15,677	12,747	81
15	21	Pennsylvania State U	2,399	921	38	82,807	54,583	66
16	22	Cornell U	2,388	1,245	52	39,822	24,232	61
17	14	U of Pennsylvania	2,380	1,966	83	8,878	5,743	65
18	23	Princeton U	2,335	1,054	45	17,964	10,521	59
19	12	Lehigh U	2,243	654	29	18,949	6,449	34
20	15	Georgia Inst. of Technology	2,142	1,278	60	88,315	52,700	60
		Total, first 20 institutions	**$ 69,957**	**$37,705**	**54%**	**$ 902,099**	**$ 599,462**	**66%**
21	25	Purdue U	2,073	1,174	57	32,206	19,612	61
22	34	U of California, Los Angeles	2,011	1,534	76	21,497	15,733	73
23	24	California Inst. of Technology	2,001	1,825	91	17,407	14,798	86
24	29	Auburn U	1,928	899	47	15,775	9,124	58
25	20	U of Washington	1,911	1,014	53	16,374	11,296	69
26	28	U of Houston	1,882	815	43	6,725	2,999	45
27	31	U of California, Santa Barbara	1,845	1,645	89	13,461	11,178	83
28	26	U of California, Berkeley	1,774	1,129	64	42,432	25,371	60
29	4	New Mexico Inst. of Mining & Tech.	1,712	308	18	15,114	3,874	26
30	37	Carnegie Mellon U	1,637	1,267	77	25,548	14,005	55
		Total, first 30 institutions	**$ 88,731**	**$49,315**	**56%**	**$1,108,638**	**$ 727,452**	**66%**
		NATIONAL TOTAL	**$154,392**	**$79,153**	**51%**	**$2,083,745**	**$1,224,617**	**59%**

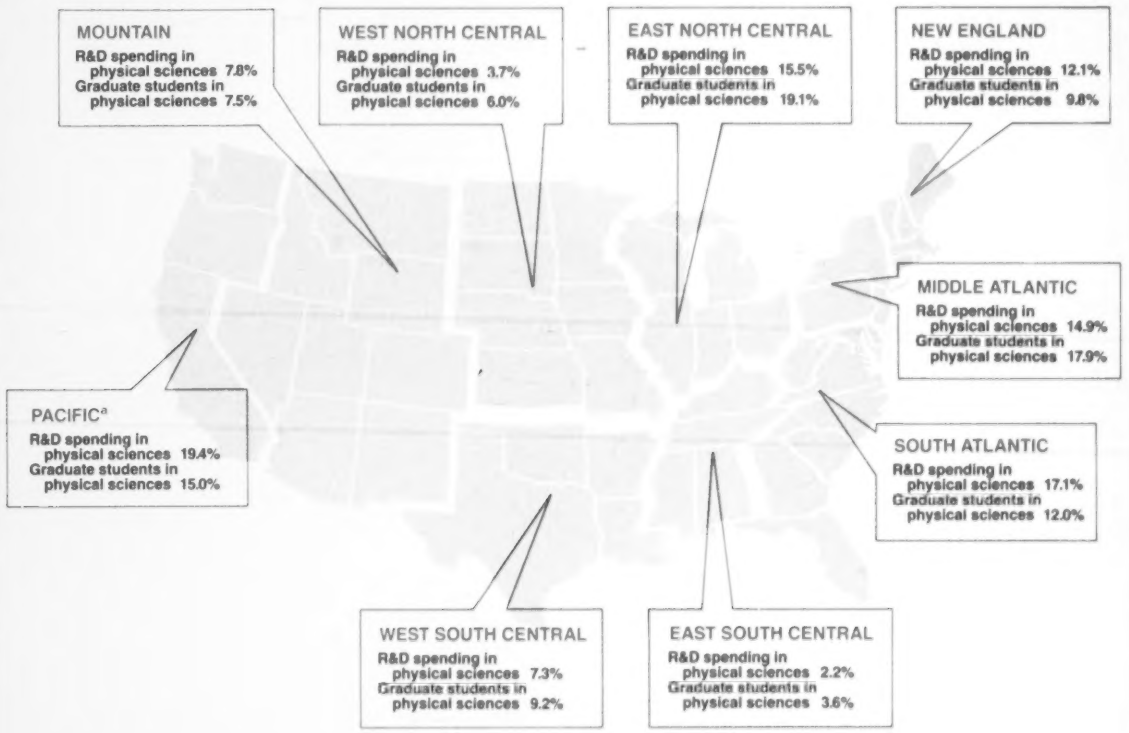
Note: Data for fiscal 1988. a Estimated. **Source:** National Science Foundation

FOREIGN GRADUATE STUDENTS: They now represent almost a third of total

	1988 Thousands	1988 % of total	1987 Thousands	1987 % of total	1986 Thousands	1986 % of total	1985 Thousands	1985 % of total	1984 Thousands	1984 % of total	1983 Thousands	1983 % of total	Annual change 1987–88	Annual change 1983–88
All sciences	**49.3**	**27%**	**46.2**	**26%**	**43.7**	**25%**	**40.0**	**23%**	**36.4**	**21%**	**35.2**	**20%**	**7%**	**6%**
Psychology and social sciences	13.9	20	13.1	18	12.7	18	12.1	18	11.1	16	11.2	16	6	4
Mathematical and computer sciences	11.6	44	11.0	42	10.4	41	9.5	41	8.3	40	7.6	39	6	10
Biological sciences	8.9	23	7.9	21	7.0	19	6.2	17	5.6	16	5.3	15	12	11
Biochemistry	1.3	28	1.2	26	1.1	23	1.0	22	0.8	20	0.8	19	9	11
Physical sciences	10.2	37	9.8	35	9.3	34	8.3	32	7.4	30	7.0	29	4	8
Chemistry	5.2	33	4.8	31	4.4	28	4.0	26	3.5	24	3.4	23	8	9
Physics	4.8	43	4.8	43	4.7	44	4.1	41	3.8	38	3.5	38	1	7
Agricultural sciences	2.5	29	2.5	30	2.5	28	2.3	26	2.3	25	2.4	25	0	1
Environmental sciences	2.1	21	1.9	19	1.8	16	1.6	15	1.6	14	1.7	14	12	5
Engineering	**28.4**	**46**	**27.4**	**45**	**26.4**	**45**	**23.5**	**43**	**22.6**	**42**	**22.2**	**42**	**4**	**5**
Chemical	2.4	44	2.3	41	2.2	39	2.2	40	2.1	37	2.2	38	3	1
Metallurgical and materials	1.6	47	1.6	47	1.5	45	1.3	42	1.2	42	1.2	43	2	7
TOTAL	**77.7**	**32%**	**73.7**	**31%**	**70.1**	**30**	**63.5**	**28**	**59.0**	**26**	**57.5**	**26**	**5%**	**6%**
ANNUAL CHANGE	**5.4%**		**5.1%**		**10.3%**		**7.6%**		**2.6%**		**8.1%**			

Note: Data are for full-time graduate students at Ph.D-granting institutions only. The percent of total is the percent of all full-time graduates in each area who are foreign. **Source:** National Science Foundation

R&D funding and graduate students in physical sciences are highest in East and Far West


MOUNTAIN
R&D spending in physical sciences 7.8%
Graduate students in physical sciences 7.5%
WEST NORTH CENTRAL
R&D spending in physical sciences 3.7%
Graduate students in physical sciences 6.0%
EAST NORTH CENTRAL
R&D spending in physical sciences 15.5%
Graduate students in physical sciences 19.1%
NEW ENGLAND
R&D spending in physical sciences 12.1%
Graduate students in physical sciences 9.8%
MIDDLE ATLANTIC
R&D spending in physical sciences 14.9%
Graduate students in physical sciences 17.9%
PACIFIC[a]
R&D spending in physical sciences 19.4%
Graduate students in physical sciences 15.0%
SOUTH ATLANTIC
R&D spending in physical sciences 17.1%
Graduate students in physical sciences 12.0%
WEST SOUTH CENTRAL
R&D spending in physical sciences 7.3%
Graduate students in physical sciences 9.2%
EAST SOUTH CENTRAL
R&D spending in physical sciences 2.2%
Graduate students in physical sciences 3.6%

Key to map: Using the Middle Atlantic states as an example, 14.9% of all R&D expenditures in the physical sciences and 17.9% of all graduate students in physical sciences are in this area. The figures for funding apply to Ph.D.-granting universities and colleges only. The figures for students apply to all universities and colleges.

Note: Data are based on $1.5 billion of R&D expenditures and 33,047 graduate students in the physical sciences enrolled in colleges and universities during the 1988 fiscal year. a Includes Alaska, Hawaii, and outlying areas. **Source:** National Science Foundation

GRADUATE SCIENCE STUDENTS: Number in chemistry falls for first time in more than a decade

Thousands	1988	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978	Annual change 1987–88	Annual change 1978–88
All sciences	250.6	246.2	242.6	238.0	233.4	232.5	231.4	228.0	227.1	219.8	213.9	2%	2%
Psychology and social sciences	107.6	105.6	103.1	102.2	102.0	104.2	107.3	108.7	109.7	105.8	101.2	2	9
Biological sciences	44.7	43.6	43.4	42.5	41.9	41.6	41.9	42.0	42.7	42.6	43.1	2	0
Biochemistry	4.9	4.8	4.9	4.7	4.5	4.2	4.1	4.0	4.0	3.9	4.0	3	2
Mathematical and computer sciences	43.8	42.3	40.9	39.1	35.4	33.2	30.3	27.1	25.0	22.7	21.5	4	7
Physical sciences	31.3	31.0	30.5	29.3	28.4	27.7	26.5	25.8	25.4	24.9	24.7	1	2
Chemistry	17.5	17.7	17.6	17.2	16.6	16.5	15.8	15.2	15.1	14.9	14.8	−1	2
Physics	12.8	12.3	12.0	11.3	11.0	10.5	10.0	9.9	9.6	9.3	9.2	4	3
Environmental sciences	13.0	13.4	14.1	14.3	14.3	14.3	13.8	13.1	12.8	12.6	12.2	−3	1
Agricultural sciences	10.3	10.3	10.7	10.7	11.3	11.5	11.6	11.3	11.6	11.3	11.1	0	−1
Engineering	97.0	97.0	95.8	90.2	87.1	85.3	78.2	74.4	70.1	67.2	64.3	0	4
Chemical	6.5	7.0	6.9	7.0	7.2	7.4	6.9	6.3	5.9	5.4	5.2	−7	2
Metallurgical and materials	4.2	4.2	4.0	3.8	3.6	3.3	3.0	3.0	2.8	2.7	2.5	−1	5
Petroleum	0.7	0.8	0.7	0.8	0.7	0.7	0.6	0.5	0.5	0.4	0.4	−10	6
TOTAL	347.5	343.2	338.3	328.3	320.5	317.9	309.5	302.4	297.3	287.0	278.1	1	2
ANNUAL CHANGE	1%	1%	3%	2%	1%	3%	2%	2%	4%	3%	1%		

Note: Data for Ph.D.-granting institutions only. **Source:** National Science Foundation

U.S. Lead in Worldwide R&D Slipping

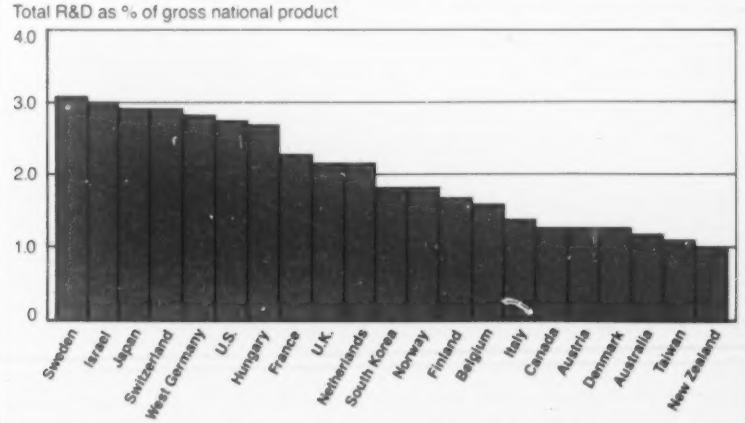
WORLDWIDE R&D SCIENTISTS AND ENGINEERS: Strong upturn for Japan in 1988

Thousands	1988	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978	Annual change 1987–88	Annual change 1978–88
U.S.	949	923	897	849	798	752	711	683	651	615	587	3%	5%
Japan	462	418	406	381	370	342	330	318	303	282	273	11	5
West Germany	na	166[a]	156[a]	148	137[a]	131	128[a]	125	121[a]	117	114	6[b]	—
France	na	109[a]	105[a]	102	98	93	90	86	75	73	71	4[b]	—
U.K.	na	101	102	98	96[a]	94	na	96	na	na	88	−1[b]	—
Per 10,000 in labor force													
U.S.	na	75.9	75.0	72.5	69.2	66.4	63.6	61.9	60.0	57.7	56.5	—	—
Japan	na	68.8	67.4	63.9	62.4	58.1	57.1	55.6	53.6	50.4	49.4	—	—
West Germany	na	58.7	52.3[a]	51.6	49.6[a]	47.4	46.4[a]	45.5	44.3[a]	43.4	42.7[a]	—	—
France	na	44.9	43.8[a]	42.8	41.1	39.1	37.9	36.3	32.1	31.4	30.7	—	—
U.K.	na	35.9	35.5	35.5	35.5[a]	35.4	na	35.8	na	na	33.3	—	—

Note: Table represents all scientists and engineers engaged in R&D on a full-time equivalent basis except Japan, whose data include persons primarily employed in R&D in the natural sciences and engineering, and all higher education natural science and engineering faculty. The U.K. data include only the government and industry sectors. The figures for West Germany increased in 1979 partially because of increased coverage of small and medium-size enterprises not surveyed in 1977. The data for France increased in 1981 in part due to a reevaluation of university research efforts. **na** = not available. a Estimated. b Annual change for 1986–87. **Source:** National Science Foundation

Five countries spend more of GNP on R&D than U.S.

Total R&D as % of gross national product



Sources: Organization for Economic Cooperation & Development, National Science Foundation

WORLDWIDE R&D EXPENDITURES: U.S. spends more than double its nearest competitor

$ Millions, constant 1982		% of GNP	$ Millions, constant 1982		% of GNP	$ Millions, constant 1982		% of GNP
U.S. (1988)	$111,503	2.8%	**Switzerland** (1986)	$2516	2.9%	**Norway** (1987)	$1006	1.8%
Japan (1988)	42,314	2.9	**South Korea** (1987)	1945	1.8	**Yugoslavia** (1987)	976	0.8
West Germany (1988)	20,068	2.8	**Australia** (1986)	1921	1.2	**Finland** (1988)	911	1.7
France (1988)	14,591	2.3	**India** (1986)	1858	0.9	**Mexico** (1984)	881	0.6
U.K. (1986)	13,742	2.2	**Belgium** (1986)	1616	1.6	**Denmark** (1985)	707	1.3
Italy (1988)	7,918	1.4	**Spain** (1986)	1547	0.6	**Israel** (1983)	637	3.0
Canada (1988)	5,300	1.3	**Brazil** (1985)	1448	0.7	**Hungary** (1987)	588	2.7
Netherlands (1986)	3,341	2.2	**Argentina** (1981)	1087	0.4	**Taiwan** (1985)	505	1.1
Sweden (1987)	2,901	3.1	**Austria** (1988)	1034	1.3	**New Zealand** (1987)	246	1.0

Note: Data are for the most current year available (in parentheses). Countries differ in statistical collection capabilities and definitions. In addition, some R&D/gross national product percentages are R&D/gross domestic product. Foreign currency conversions to U.S. dollars were calculated with Organization for Economic Cooperation & Development purchasing power parities or using International Monetary Fund average-for-period par/market exchange rates. **Source:** National Science Foundation

TOTAL AND NONDEFENSE R&D: Japan's R&D spending is rising much faster than U.S.'s

$ Billions, constant 1982	1988	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978	Annual change 1987–88	Annual change 1978–88
TOTAL R&D													
U.S.[a]	$111.5	$108.4	$105.3	$102.6	$93.9	$85.8	$80.0	$76.4	$73.0	$69.9	$66.7	3%	5%
Japan	42.3	39.2	36.6	36.1	32.4	29.9	27.4	25.5	23.1	21.0	19.1	8	8
West Germany	19.4	19.4	18.6	18.5	16.9	16.4	16.3	15.9	15.3	15.0	13.3	0	4
France	14.6	14.0	13.6	13.1	12.6	11.9	11.5	10.8	9.8	9.4	8.9	4	5
U.K.	13.8	13.8	13.6	12.8	na	11.9	na	12.2	na	na	11.1	0	2
NONDEFENSE R&D													
U.S.[a]	$ 80.3	$ 78.0	$ 73.7	$ 71.8	$66.7	$61.8	$58.4	$57.3	$54.8	$51.7	$48.7	3%	5%
Japan	42.0	38.9	36.4	35.9	32.4	29.9	27.5	25.7	23.3	21.1	19.1	8	8
West Germany	19.1	18.5	17.4	17.1	16.2	15.3	15.8	15.2	14.5	14.2	12.5	3	4
France	11.3	11.0	10.7	10.5	9.9	9.4	9.1	8.1	7.6	7.4	7.2	3	5
U.K.	10.5	10.3	10.2	9.1	na	8.5	na	8.7	na	na	8.0	2	3

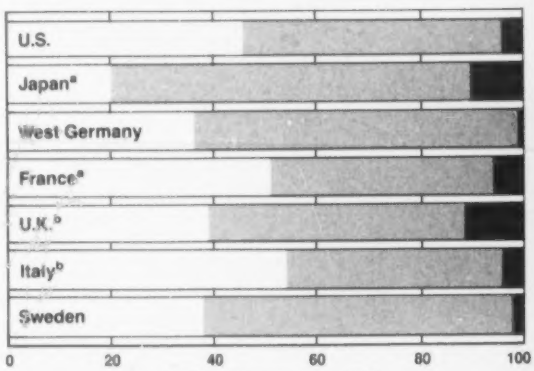
Note: Foreign currency conversions to U.S. dollars are calculated based on Organization for Economic Cooperation & Development purchasing power parity exchange rates. a C&EN estimates based on NSF data. na = not available. **Source:** National Science Foundation

ORIGIN OF CHEMICAL LITERATURE: Half comes from U.S., U.S.S.R., and Japan

% of total[a]	1989	1985	1981	1977	1973
U.S.	27.8%	27.0%	27.4%	25.6%	26.4%
U.S.S.R.	12.7	14.9	16.6	23.2	24.7
Japan	11.8	11.3	10.5	8.2	7.5
West Germany	6.2	6.2	6.0	6.0	5.3
U.K.	5.7	5.8	6.1	6.2	6.0
France	4.2	4.3	4.2	4.2	4.3
China	3.7	2.6	1.4	0.1	0.0
Canada	3.0	2.9	2.6	2.7	2.8
India	2.8	3.0	3.3	3.0	2.6
Italy	2.3	2.4	2.2	1.9	1.9
Poland	1.6	1.7	2.1	2.1	2.0
Netherlands	1.5	1.4	1.3	1.2	1.1
Spain	1.4	1.2	0.7	0.6	0.4
Australia	1.2	1.4	1.4	1.2	1.1
East Germany	1.2	1.2	1.3	1.2	1.1
Sweden	1.2	1.2	1.1	1.1	1.1
Czechoslovakia	1.1	1.1	1.3	1.4	1.7
Switzerland	1.1	1.1	1.1	1.0	0.9
All others	9.5	9.3	9.4	9.1	9.3
TOTAL PAPERS (THOUSANDS)	397.2	380.1	374.0	348.1	269.7

a Source of journal literature abstracted in *Chemical Abstracts* based on author's address. **Source:** Chemical Abstracts Service

Government's share of R&D funding is greatest in France and Italy



a Estimated b Data are for 1987 **Sources:** Organization for Economic Cooperation & Development, National Science Foundation, individual nations